SCIENCE

17 April 1959

Volume 129, Number 3351

Editorial Basic Research a Luxury? 995

Articles Neuron Doctrine and Electrophysiology: *T. H. Bullock* 997

A quiet revolution has been taking place in our concepts of how the nerve cells act alone and in concert.

Rock Magnetism: *S. K. Runcorn* 1002

The magnetization of ancient rocks bears on the questions of polar wandering and continental drift.

News of Science Scientists at Space Agency Seminar Compare Views on Composition and Origin of Van Allen Radiation Layer; recent events 1012

Book Reviews *Zoogeography,* reviewed by *P. J. Darlington, Jr.*; other reviews 1018

Reports Factors Contributing to Production of "Virus-Free" Tumors in Turkeys by Rous Sarcoma Virus: *V. Groupé* and *F. J. Rauscher* 1022

Two Antigenically Different γ-Globulins in Domestic Rabbits Revealed by Isoprecipitins: *S. Dray* and *G. O. Young* 1023

Development of a Chick Embryo Heart Cell for the Cultivation of Poliovirus: *J. E. Prier* and *R. Sullivan* 1025

Failure of Survival of Slowly Growing Members of a Population: *S. M. Rose* 1026

Neopilina (*Vema*) *ewingi,* a Second Living Species of the Paleozoic Class Monoplacophora: *A. H. Clarke, Jr.,* and *R. J. Menzies* 1026

Departments Letters 992

Logan Meeting of the Pacific Division of the AAAS; Meeting Notes; Forthcoming Events; New Products 1028

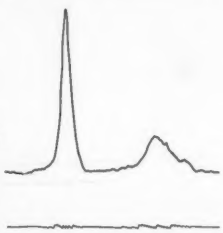
AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

PAPER ELECTROPHORESIS

... now more useful than ever in analyzing biological materials

Thousands of laboratories routinely run serum proteins by paper electrophoresis as an aid in diagnosing hepatitis, agammaglobulinemia, the myelomas and a variety of related pathologies. Now this simple diagnostic aid is being used to separate other serum components of medical significance.

LIPOPROTEINS

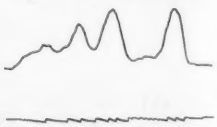


The relationship between these fat-protein molecules and atherosclerosis, liver diseases, diabetes and obesity has made lipoproteins an important field of research.

HEMOGLOBINS

Sickle cell anemia is revealed by the presence on the paper strip of both normal and sickle-cell hemoglobins.

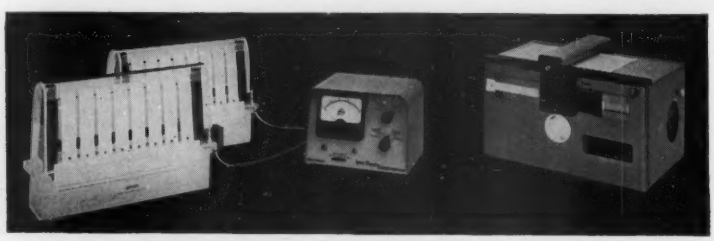
GLYCOPROTEINS



Changes in glycoproteins are often greater and more specific than changes in serum proteins. Indications of glycoprotein correlations are reported in studies of cancer, collagen diseases, acute and chronic infections and tuberculosis.

These new analyses can be performed on the same Model R equipment chosen by most laboratories using paper electrophoresis. The equipment is easy for technicians to use, gives uniform, reproducible results, and lends itself readily to different analyses, dyes and techniques. For more information, please return coupon below.

Beckman® / **Spinco Division**
Beckman Instruments, Inc.



Beckman/Spinco Model R System: electrophoresis cell, power supply and scanner

R-5H

To: Spinco Division, Beckman Instruments, Inc., Stanford Industrial Park, Palo Alto 5, California

☐ Please send me information on the clinical significance of paper electrophoresis, and a description of the equipment required.

☐ I own a Model R System and would like additional information on recently-reported methods.

NAME _____

INSTITUTION _____

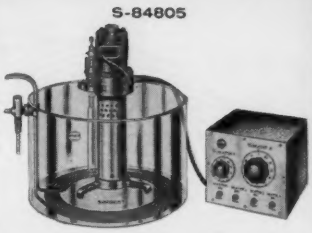
ADDRESS _____

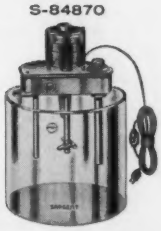
_____

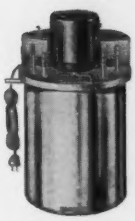
SCIENCE is published weekly by the AAAS, 1515 Massachusetts Ave., N.W, Washington 5, D.C. Entered at the Lancaster, Pa., Post Office as second class matter under the act of 3 March 1879. Annual subscriptions: $8.50; foreign postage, $1.50; Canadian postage, 75¢.

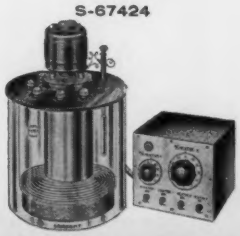
A complete line of Sargent LABORATORY BATHS DESIGNED for your specific needs

precise—economical—multi-purpose









FIVE WATER BATHS

S-84810 WATER BATH—Constant Temperature, Full Visibility, Thermonitor Controlled, 0.01°C, Sargent.

S-84805 WATER BATH—Constant Temperature, Full Visibility, 0.01°C, Sargent.

S-84860 WATER BATH—Constant Temperature, Full Visibility, 0.1°C, Sargent.

S-84870 WATER BATH—Constant Temperature, Full Visibility, Economy Model, 0.25°C, Sargent.

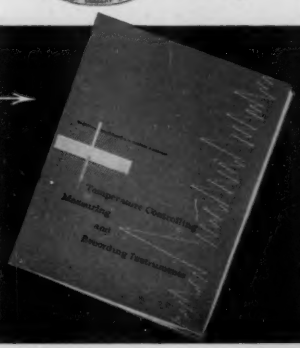
S-84880 LIQUID CIRCULATOR—Constant Temperature, 0.1°C, Sargent.

VISCOSIMETER BATHS for Kinematic Viscosity Measurements

S-67424 VISCOSIMETER BATH—Kinematic, Double Wall, High Precision, 0.02°F, Sargent.

S-67428 VISCOSIMETER BATH—Thermonitor Controlled, Kinematic, Double Wall, High Precision, 0.02°F, Sargent.

Write for Sargent Bulletin T on Temperature Controlling, Measuring and Recording Instruments



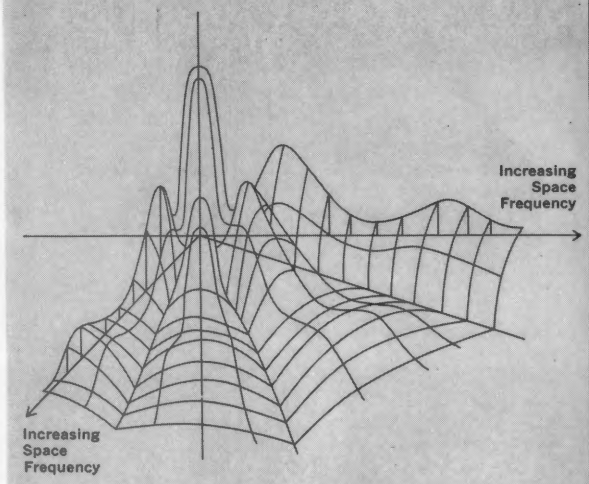
SARGENT

SCIENTIFIC LABORATORY INSTRUMENTS • APPARATUS • SUPPLIES • CHEMICALS

SARGENT

E. H. SARGENT & COMPANY, 4647 W. FOSTER, CHICAGO 30, ILLINOIS

DETROIT 4, MICH. • DALLAS 35, TEXAS • BIRMINGHAM 4, ALA. • SPRINGFIELD, N. J.



Phosphor bronze reticle (actual size) and space frequency transfer characteristics of circular aperture reticle.

TARGET DISCRIMINATION IN INFRARED DETECTION SYSTEMS

The pioneering field of infrared detection offers many challenging opportunities to scientists and engineers at Ramo-Wooldridge for advanced studies in the solution of target discrimination problems. Research is continually under way at Ramo-Wooldridge in the integrating of infrared detection devices with the latest electronic systems techniques for enhanced target detection on the ground and in the air.

The phosphor bronze reticle, or image chopper, illustrated above was developed by Ramo-Wooldridge. It indicates a marked stride in space filtering discrimination concepts, and is used for target signal enhancement in guided missiles, anti-aircraft fire control and air collision warning applications.

The reticle is used in the focal plane of an infrared optical system and is rotated to chop the target image for the desired space filtering. It is also employed in time filtering, such as pulse length discrimination, or pulse bandwidth filtering.

Space filtering is critical to infrared systems, because of its ability to improve the detection of objects located in the midst of background interference. In a manner similar to that used in the modification of electronic waveforms by electrical filtering, space filtering enhances the two-dimensional space characteristics of a target. The size and features of the target are highlighted and the undesired background eliminated.

Scientists and engineers with backgrounds in infrared systems—or any of the other important areas of research and development listed below—are invited to inquire about current opportunities at Ramo-Wooldridge.

Electronic reconnaissance and countermeasures systems
Analog and digital computers
Air navigation and traffic control
Antisubmarine warfare
Basic research
Electronic language translation
Information processing systems
Advanced radio and wireline communications
Missile electronics systems

RAMO-WOOLDRIDGE

P. O. BOX 90534 AIRPORT STATION • LOS ANGELES 45, CALIFORNIA

a division of *Thompson Ramo Wooldridge Inc.*

EXPERIMENT:

The analytical determination of proper balance between price and performance in lab glassware

Here's an experiment which you will be interested in trying. Though it pertains more to economy than to a physical state or condition, it does offer the sound analytical reasoning which you, as a scientist, must welcome.

The premise is this: laboratory glassware is an "expense" item in schools and colleges and by cutting this expense substantially every science instructor makes available to himself additional money with which to purchase other equipment for his laboratory.

This premise is based, first, on the fact that *quality* is maintained and, second, that the saving involved is substantial enough to warrant this time necessary to effect it.

Actually, this experiment demands little analytical determination to ascertain the possible savings involved. One glance at the comparative price chart listed below will show you the kind of savings to which we refer.

Remember . . . these prices are for Doerr Diamond D *quality* glassware . . . glassware which we are proud to emblazon with our Diamond D trade mark.

If you want facts to prove to school officials and school boards your contention that you can effect substantial savings on laboratory glassware, send for our booklet, "FACTS" . . . About The Economics Of Laboratory Glassware". Write to: Doerr Glass Company, Dept. M, Vineland, N. J.

COMPARATIVE LIST PRICE CHART

ITEM	BRAND A	BRAND B	DOERR
PIPETTE (1 ml in 0.01) (Serological)	$1.31	$1.57	$0.90
PIPETTE (5 ml) (Volumetric)	1.19	1.36	0.79
PIPETTE (1 ml) (Ostwald)	1.14	1.28	0.81
CENTRIFUGE TUBE (15 ml)	1.28	1.28	0.69
FLASK (100 ml) (Glass Stoppered)	2.73	3.01	1.99
CYLINDER (100 ml)	2.71	2.94	1.48
SEPARATORY FUNNEL (250 ml) (Squibb)	6.22	6.56	5.21

NOTE: All Diamond D glassware is sold exclusively through laboratory supply dealers and cannot be purchased direct. We will gladly send you the address of the nearest lab supply house that carries the Diamond D lines.

Please send me FACTS BOOK

NAME _____ TITLE _____

COMPANY _____

STREET _____

CITY _____ STATE _____

DIAMOND "D" GLASSWARE

Quality Begins With Price And Ends With Performance

Letters

Presentation before Publication

It was a surprise to me to find that the editorial entitled "Behind the *Times*" [*Science* **129**, 301 (1959)] suggested a journal policy of refusal to release any information to newspaper reporters prior to publication of an article. In many cases the researcher, or member of the research team, has already released such information in full by presentation at national conventions, regional meetings, or state-level programs. Large professional gatherings have established press rooms where abstracts or manuscripts originally submitted to the program committee have been made available to journalists. To further temper journalistic extrapolation with scientific caution, interviews have been arranged between speakers and reporters.

The editorial writer noted ". . . that journals are not the only means of communication in the scientific world. . . . Consequently, on occasion a reporter will come upon a piece of research that he finds newsworthy, but which . . . has not yet appeared [in print]." The phrase *on occasion* seems too limited; *often* or *frequently* would seem to be better choices.

A previous editorial [*Science* **127**, 1145 (1958)] reminded us that science did not exist until communication was established among scientists. Denial of scientific information to the wide audience covered by newspapers may possibly hamper the development of science. For surely scientists today do not wish to communicate exclusively with their colleagues. Hyperspecialization has made that undesirable. What scientists read in their professional literature may contain no more information than what they hear at their periodic assemblages. Since reporters are encouraged to attend many such gatherings, it seems churlish to deny them access to the contents of journals prior to publication.

The responsibility for an accurate report lies with the scientist. The responsibility for an accurate interpretation lies with the reporter, whether he reads a manuscript, hears a paper, or studies an article.

DELL LEBO
Child Guidance and Speech Correction Clinic, Jacksonville, Florida

The Word "Ecology"

It has been stated by a number of historians of science that the word *ecology* was coined by the German naturalist and Darwinian Ernst Heinrich Haeckel (1834–1919). Indeed, the *Oxford English Dictionary* attributes the first use of the word to Haeckel's *The History of Creation* (1875), quoting both from the preface of this work (in translation, "The great series of phenomena of comparative anatomy and ontogeny . . . chorology and oecology") and from Haeckel's *Evolution of Man* (1879) ("All the various relations of animals and plants to one another and to the outer world, with which the Oekology of organisms has to do . . ."). The *Encyclopedia Britannica* says in its article on "Ecology": "In 1869 Ernst Haeckel stated that the individual was a product of co-operation between the environment and organismal heredity. This relationship was called 'oecology'." Paul B. Sears in his book *Charles Darwin: The Naturalist as a Cultural Force* (Scribner's, 1950) writes (page 42): "Haeckel's grasp of the problems of living nature is suggested by the fact that he coined the word 'oecology,' now 'ecology,' to cover the study of the broad configurations which exist within and among communities of organisms," and in the same work (page 56) Sears pins down the date of this coinage to the year 1866. George Sarton, in *A History of Science* (Harvard University Press, 1952), repeats this attribution to Haeckel.

Recently, in reading *The Correspondence of Henry David Thoreau*, edited by Walter Harding and Carl Bode (New York University Press, 1958), I came across a use of the word *ecology* antedating Haeckel's by several years. In a heretofore unpublished letter to his cousin George Thatcher, of Bangor, Maine, dated 1 January 1858, Thoreau wrote: "Mr Hoar is still in Concord, attending to Botany, Ecology, &c with a view to make his future residence in foreign parts more truly profitable to him." Edward Hoar was Thoreau's Concord neighbor and his companion on several trips, including the famous journey to the Maine woods in 1857. The casualness with which Thoreau used the word *ecology* would certainly indicate that it was not of his own mintage and that his cousin would understand it. The inference, too, is that Hoar knew it also.

Thoreau was a wide reader in the literature of natural history. He had read *The Voyage of the Beagle* and quotes it in his *Journal*. We have no record that he had read Haeckel. In fact, in 1858 Haeckel was only 24 years old, probably then studying medicine, with his biological career still ahead of him.

So, who did coin the word *ecology*? And where did Thoreau and Hoar pick up the word? It would be interesting to know, for Thoreau was certainly an ecologist and possessed a fundamental understanding of the principles of ecology, though it did not attain the stature of a recognized science until long after his day.

PAUL H. OEHSER
Smithsonian Institution, Washington, D.C.

Now in Sterile Strip Pack...

OTHER FALCON LABWARE FOR EFFICIENT BIOLOGICAL PROCEDURES:

- Round and square Petri dishes
- Bi plate . . . grid plate . . . and radial counting plate
- Box-type culture dishes
- Tissue culture plates
- Assay spyders
- Culture tubes and swubes
- Microdiffusion dishes
- Phage typing grids
- Liquid-Tite and other disposable fluid containers

Write direct to Falcon for samples. Leading dealers convenient to you carry Falcon Products available for immediate delivery. Ask for prices and information.

INSTANTLY IDENTIFIED

Streptococcus...its distinctive characteristics are INSTANTLY IDENTIFIED

Falcon Disposable Plastic Petri Dishes are also INSTANTLY IDENTIFIED for added efficiency and added economy.

Falcon Disposable Plastic Tubes

"SEALED IN" sterility from origin to instant of use

Falcon clear styrene disposable tubes are now available in a modern, sterile, strip pack. This convenient package insures unit sterility of both tube and cap...ready to use without costly, time-consuming autoclaving or washing.

For quick use...tubes are removed by tearing the paper backing across either end of the tube.

For surgical sterility...tubes are removed by peeling cellophane from the face of the pack.

Falcon low cost, one-use tubes and caps are chemically clean...biologically inert...and free of trace substances that may leach out to affect critical work.

They are ideal for blood samples, antibiotic titrations, agar slants, broth tubes, blood clot retractions and centrifuging at moderate speeds. Withstands prolonged heating at over 80°C with high resistance to both breakage and distortion.

The polyethylene caps feature two positions...a controlled loose fit for aerobic culturing and a tight seal to prevent spillage and evaporation.

Packaged STERILE...delivered STERILE...these Falcon disposable plastic tubes are available in this new, ready-to-use package at the same low cost.

NUMBER AND DESCRIPTION OF TUBES IN NEW PACKAGE:

T17100C, 17mm x 100mm, Clear, Tube and Cap
T17100CNC, 17mm x 100mm, Clear, Tube (no cap)
T17100HTP, 17mm x 100mm, Hi Temp Poly, Tube (no cap)

T1275C, 12mm x 75mm, Clear, Tube and Cap
T1275CNC, 12mm x 75mm, Clear, Tube (no cap)
T1275HTP, 12mm x 75mm, Hi Temp Poly, Tube (no cap)

Falcon products will be exhibited . . .

May 11-14 — Society of American Bacteriologists — St. Louis, Mo.

June 14-17 — American Society of Medical Technologists — Phoenix, Arizona

FALCON PLASTICS

6016 West Washington Boulevard, Culver City, California
A Division of Becton, Dickinson and Company

FIRST AND FOREMOST IN DISPOSABLE PLASTIC LABORATORY EQUIPMENT

17 April 1959, Volume 129, Number 3355

SCIENCE

SCIENCE, which is now combined with THE SCIENTIFIC MONTHLY, is published each Friday by the American Association for the Advancement of Science at Business Press, Lancaster, Pa. The joint journal is published in the SCIENCE format. Entered at the Lancaster, Pa., Post Office as second class matter under the Act of 3 March 1879. SCIENCE is indexed in the *Reader's Guide to Periodical Literature*.

Editorial and personnel-placement correspondence should be addressed to SCIENCE, 1515 Massachusetts Ave., NW, Washington 5, D.C. Manuscripts should be typed with double spacing and submitted in duplicate. The AAAS assumes no responsibility for the safety of manuscripts or for the opinions expressed by contributors. For detailed suggestions on the preparation of manuscripts, book reviews, and illustrations, see *Science* 125, 16 (4 Jan. 1957).

Display-advertising correspondence should be addressed to SCIENCE, Room 740, 11 West 42 St., New York 36, N.Y.

Change of address notification should be sent to 1515 Massachusetts Ave., NW, Washington 5, D.C., 4 weeks in advance. If possible, furnish an address stencil label from a recent issue. Be sure to give both old and new addresses, including zone numbers, if any.

Annual subscriptions: $8.50; foreign postage, $1.50; Canadian postage, 75¢. Single copies, 35¢. Cable address: Advancesci, Washington.

Basic Research a Luxury?

Although, as we pointed out earlier on this page (3 April 1959), science and technology form the indispensable basis for the solution of Israel's economic problems, Israeli scientists, technologists, lay citizens, and government officials do not agree about the role of basic research. The question, in its bluntest form, is: How much, if any, of the national effort should be devoted to pure research?

This question is the subject of searching discussion in Israel, and the reasons it is framed in this form are not far to seek. The country is ringed about by hostile states and must consequently devote a large share of her effort to the maintenance of her armed forces; her commitment to accept immigrants forces her to allocate another large share of her resources to preparations for housing, and finding work for, tens of thousands annually. The recent increase in immigration from Romania has forced Israel to impose upon her citizens a stiff compulsory loan on top of income taxes and import duties that dwarf those in this country. So much for the internal difficulties; there are external ones as well. Israel has an adverse balance of trade greater than $200 million per year. This dollar gap is currently filled by funds from private philanthropy, U.S. Government projects, the sale of bonds, and German reparations. But all these fluctuate in amount, and one of them at least, the German reparations, will come to an end between 1962 and 1964.

In view of these economic realities, it is not surprising to find that many government officials and some scientists with technological leanings think that Israel should devote all or nearly all of her resources for research to applied science. They contend that Israel is too limited in manpower and other resources to support basic research and that such research is a luxury the country cannot afford. Two scientists who share this attitude expressed it thus: "The country is too small to have specialized research," and "Basic science does not pay in Israel."

Those whose orientation is toward basic research take quite a different position. They think the country can, and indeed must, have both kinds of research. They take the view that even in a country that faces harsh economic problems, basic research will be practical in the long run, for without it no advanced technology can be kept vigorous; that quite aside from economic considerations, basic research is an important cultural activity; that Israel gains intangible but nevertheless valuable world recognition and status from her accomplishments in pure science; and, finally, that Israel has a historic role to play as a scientific outpost in the Middle East.

The practice of basic research in Israel antedates the formation of the state: this month the Daniel Sieff Research Institute, which formed the nucleus for the Weizmann Institute, celebrates its 25th anniversary, and the Hebrew University was founded in 1925, the Technion in 1924. These institutions have been supported in part by foreign private philanthropy and, in recent years, by research contracts from United States government agencies, among them the Department of Defense, the Atomic Energy Commission, and the National Science Foundation.

Both the strong tradition of basic research in Israel and the prospect of continuing outside support make it likely that basic research will survive the present crisis.—G. DuS.

17 April 1959, Volume 129, Number 3355 SCIENCE

CURRENT PROBLEMS IN RESEARCH

Neuron Doctrine and Electrophysiology

A quiet revolution has been taking place in our concepts of how the nerve cells act alone and in concert.

Theodore Holmes Bullock

The neuron doctrine, which we chiefly owe to Cajal (*1*), was unquestionably a giant stride forward in the understanding of the substratum of nervous function. It forms the basis of all modern work on the nervous system. It asserts that the nerve cell and its processes, together called the neuron, form the cellular units of the nervous system which are directly involved in nervous function; that all nerve fibers are neuronal processes; that the neuron and all its extensions develop embryologically from a single neuroblast; and that the neuron is a trophic unit, all its processes being dependent upon the nucleated cell body for their maintenance and regeneration. Although this is not inherent in the original anatomical concept, the neuron has classically come to be regarded as a functional unit, and it is here that newer information forces a reappraisal.

We can appreciate the significance of the neuron doctrine more fully by visualizing the alternative concepts historically available (*2*). In various forms, these alternatives, as formulated by Gerlach in the '70's and by Golgi, Meynert, Weigert, Held, Apathy, Bethe, and Nissl, among others, during several subsequent decades, assumed a diffuse reticulum of anastomosing dendritic and axonal processes. The "reticularists," as this heterogeneous group came to be called, were united mainly in their conviction that anatomical continuity of fibers and branches was the prevalent condition in the nervous system. But without assuming some kind of discontinuity and a useful, noncapricious lability it was extremely difficult, to say the least, to analyze, in a functionally meaningful way, pathways, connections, and the processing of discrete responses through complex centers, and this difficulty became more acute after the discovery of propagating all-or-none nerve impulses.

Dr. Bullock is a member of the staff of the department of zoology, University of California, Los Angeles.

Early Evidence of Independent Neurons

Actually, the idea that nerve fibers are the greatly elongated extensions of nerve cells, though by no means generally accepted until after the time Harrison observed the outgrowth of processes in tissue culture (1907), had been clearly stated by workers in the first half of the last century (Kölliker, Wagner, and Remak). The individuality of the nerve cell in degenerative as well as in embryological processes was strongly indicated by the works of Forel and His in the '80's. But a convincing illustration of these principles and of the fact that *axons generally terminate among dendritic ramifications*—but freely and without forming a reticulum—awaited that scientific stellar nova, Santiago Ramon y Cajal. It is one of the ironies of history that his start and all his early work were based on the exploitation of a remarkable silver impregnation method discovered by the Italian Camillio Golgi in 1873 but virtually unknown until 14 years later when Cajal, among others (including the Norwegian Fridtjof Nansen, the future polar explorer), began to use it. Golgi shared with Cajal the Nobel prize of 1906 because of the crucial role his method had played in the 20 formative years of the neuron doctrine. But even at that date he had not given up his reticularism and regarded Cajal as an adversary. Flurries of controversy continued for years, but of all the contributions of neurohistologists none has stood the test of time as well as those of Cajal, as amazing for their quality as for their quantity (*3*).

As a subsidiary doctrine, Cajal made the brilliant inference from the anatomical arrangement of sensory, motor, and internuncial neurons that they are all *dynamically polarized,* usually in such a way that excitation can only be transmitted from the axon of one neuron to dendrites or soma of the next and, within a neuron, must normally spread from dendritic to axonal poles (Fig. 1).

Convergence of Physiology and Anatomy

The parallel strides made in electrophysiology during much of the same period, from the time of Helmholz in the middle of the last century to the period just before and after World War I, and the work especially of Keith Lucas, E. D. Adrian, Herbert Gasser, and Joseph Erlanger led to the discovery of the change in electrical potential with action which, in the single nerve fiber, came to be called the nerve impulse. This was found to be an all-or-none event of the order of 1 millisecond in duration and capable of following a preceding impulse only after a short interval. Thus, the concept of a quantum of activity or a *unit of function* came to be emphasized, and the nervous system

came to be regarded as a kind of digital computer with a binary—that is, yes-or-no—response. Some would prefer to call it a pulse-coded device, since the intervals between pulses are graded and can introduce noise. We can now recognize four basic tenets which grew out of the impact of electrophysiology on the neuron doctrine during this classical period of the '20's and '30's (classical from the standpoint of present-day textbooks) and which still dominate much of the thinking in the field.

1) We came to think that the all-or-none impulse was synonymous with the neuron in action—that is, that the impulse together with its afterpotentials was the only form of truly nervous activity.

2) We thought that when any part of the neuron was excited this excitation spread to all parts of the neuron as a propagated nerve impulse.

3) We thought that Cajal's doctrine of the dynamic polarity of neurons meant that dendrites propagate impulses toward the cell body.

4) We have thought for many years that the secret of all labile functions must lie in the properties of a junction between neurons. This locus, called the synapse, was supposed to be the only seat of selection, evaluation, fatigue, and facilitation and perhaps of long-persistent changes as well.

Four Main Revisions

The evidence of the last few years has significantly altered all four of these tenets.

1) We now believe that the neuron is a functional unit somewhat in the same sense that a person is in society, in that it speaks with one voice at a time. At least so long as the neuron has but one output path (in terms of the textbook vertebrate neuron, one axon), it will speak with one voice at a time in the all-or-none pulsed code output essential for long-distance propagation. But we know that some neurons have two axons and can deliver two nonidentical pulse-coded outputs at the same time in different directions (*4*). More important, we believe that this pulsed form of activity—the nerve impulse or *spike*—is only characteristic of a specialized portion of the neuron, the axon, as is explained further below.

2) We now believe that the responses of many or most parts of the neuron to impinging excitation do not spread to become impulses directly but help determine the firing of impulses at some critical region such as the base of the axon—somewhat in the same manner as the impinging sights and sounds act upon the trigger finger of a man with a pistol. These responses we will call *prepotentials* or subthreshold processes, and some of them are enumerated below.

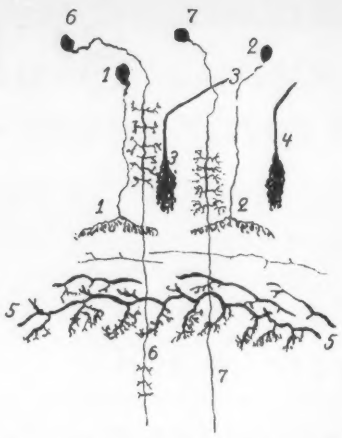


Fig. 1. Neurons of the optic ganglia (medulla externa) of a crab stained by the Golgi silver impregnation method. Since the eye is above and the brain is below, it is reasonable to assume that most transmission is downward—therefore, from terminals like 3 and 4 to upper (dendritic) processes of 6 and 7. But it is not so easy to say what direction transmission takes in the purely local neurons (1 and 2) or the coarse horizontal fibers (5). [From Hanström (*11*)]

3) We now believe that many parts of the neuron cannot respond in an all-or-none manner and therefore cannot propagate without decrement. The establishment of the conduction of the nerve impulse without decrement was one of the achievements of the '20's and early '30's but apparently applies only to a special portion of the neuron—the axon. *Decremental conduction* is probably characteristic of the great bulk of neuronal surface membrane—that is to say, the cell membrane of the extensive ramifications of dendrites making up much of the gray matter of higher animals and the neuropiles of lower. Decremental conduction requires that all such membranes be within shouting distance of the locus of spike initiation—in other words, within the distance of electrotonic spread—in order to be able to exert a physiological influence on the generation of all-or-none events by the neuron. Many dendrites are so short that we can easily believe this condition is met, but some are so long and fine that it remains seriously open to question whether they can directly influence to any significant degree the initiation of spikes by the cell or whether their main role is quite another one (Fig. 2). In this paragraph we have been traversing a no man's land from areas of more general agreement to areas of less and less agreement, and here we pass definitely into the area of personal speculation. But it has been suggested that much of the activity of dendrites has its significance in an influence upon other neurons, even though the activity is local, graded, and small in amplitude. It seems likely that brain waves are the synchronized subthreshold dendritic potentials of many neurons summed and, further, are perhaps more than a mere by-product like the noise of a car, but are a physiologically significant causal agent (*5*).

4) We now believe that labile and integrative processes, insofar as they are localizable to the single unit level, are not confined to the synapse but occur as well at other places in the sequence of events preceding the initiation of the propagated spike (*6*). There may be as many as four or five *different kinds of circumscribed loci* in various parts of the neuron, each of which is integrative in the sense that it does not pass on whatever comes to it in a one-to-one relation but exercises some labile evaluative action (Fig. 3).

These changes in viewpoint add up to a quiet but sweeping revolution. They renew the old hope that we may one day be able to explain complex behavior in terms of neurons—of their patterns and properties. In my opinion that day is still far away. But now, in contrast to a decade ago, our models do not lack degrees of freedom at the level of the physiology of the single neuron. On the contrary, the permutations of the half dozen integrative processes now known within the neuron permit so much complexity that we need rather to know what restrictions to place upon the models. However, I think we are getting closer to an explanation of one of the most basic features of the neuronal basis of behavior—namely, the mechanism of origin of *temporally patterned impulse sequences*. Such patterns are the coded commands or output of every neuron, high or low, and the problem of how the characteristic sequences within and among neurons of a group are formulated has hardly been investigated heretofore. "Characteristic" means recurrent, and if we state the problem in terms of

the mechanism of formulating a meaningful pattern and then retaining or stabilizing that mechanism, we have essentially stated in one form the basic problem of the neuronal basis of instinct as well as of learning.

Capillary Ultramicroelectrode

These drastic changes in viewpoint are almost entirely due to the technical advances made possible by the intracellular electrode, a device introduced by Ling and Gerard in 1949 (*7*) and perfected by a number of other workers, which makes it possible to record from inside the larger neurons many of the events that occur prior to the initiation of the all-or-none impulse, with but very slight damage. The electrode is a glass capillary tube drawn out to submicroscopic dimensions, of the order of a few tenths of a micron in outside diameter, filled with an appropriate salt solution as conductor and inserted into the cell to measure the electrical potential difference between the inside and a second electrode outside the cell.

The technique is not extraordinarily difficult, but under the best of conditions it presents problems. The electrodes are of high resistance—from several to many tens of megohms—and require special circuits for reasonable fidelity of recording of rapid events. They introduce many microvolts of noise. The capillary pipettes have to be drawn again and again to the same shape, carefully filled, and frequently replaced, for they break not only under the stress of a little connective tissue but of their own accord, presumably from internal stresses. While the tips are quite visible in air, they are beyond the limits of ordinary microscopy under water, and in most experiments the penetration is made blindly. A rather satisfactory sign that the tip has penetrated into a cell is provided by the sudden appearance of a negative potential of several score millivolts. The main limitation, however, aside from uncertainty about exactly where the tip is located, is the intolerance of small cells and processes—below about 10 microns—of even the finest electrodes thus far produced. Our knowledge is based on sampling from a rather small number of types of large neurons, and even here only from the axon, the cell body, and perhaps the bases of the larger dendrites.

Let us now look a little more closely at the major evidence for the main conclusions stated above.

Subthreshold Activity

Every neuron so far penetrated gives at least one output of all-or-none spikes, and a few have been encountered which can give two different rhythms of spikes and which have two axons or major processes going in different directions (*4*). But it would probably occasion less surprise today than ever before were someone to find a neuron which gave no all-or-none impulses but whose axon carried only graded and decrementally spreading activity. This may well be the primitive property, and it may well be retained in the many very short axoned neurons in the highest centers of both invertebrates and vertebrates. This is to say that the possibility remains with us that in the most complex and finely textured higher centers, made up largely of very small neurons, perhaps much of the normal functioning is carried out *without nerve impulses*—that is without all-or-none, propagated spikes but by means of graded and decrementally spreading activity. Perhaps the first direct demonstration that subthreshold events in one neuron can increase the activity in another neuron has recently been supplied by experiments of Watanabe and myself on the nine-celled ganglion of the lobster heart (*8*). Here, relatively long-lasting pulses of current repeatedly applied through the intracellular electrode into one of the five large anterior cells increased the pace of firing of small posterior cells many millimeters away, even when the applied currents were below threshold or were in the wrong polarity for spike production. (The internally anodal

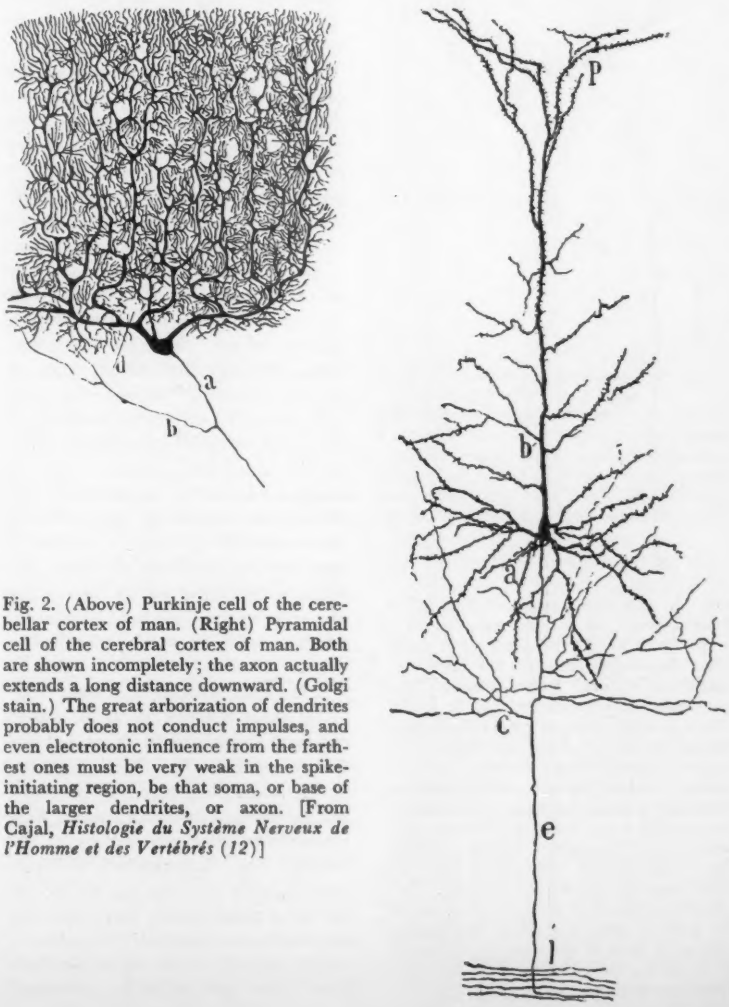


Fig. 2. (Above) Purkinje cell of the cerebellar cortex of man. (Right) Pyramidal cell of the cerebral cortex of man. Both are shown incompletely; the axon actually extends a long distance downward. (Golgi stain.) The great arborization of dendrites probably does not conduct impulses, and even electrotonic influence from the farthest ones must be very weak in the spike-initiating region, be that soma, or base of the larger dendrites, or axon. [From Cajal, *Histologie du Système Nerveux de l'Homme et des Vertébrés* (*12*)]

stimuli caused the distant small cells to tend to fire during the long pulse, while the internally cathodal currents caused the small cells to tend to fire their impulses just after termination of the current.) These effects, obtained without the intervention of nerve impulses, are not due to escape of current but occur only if the stimulated cell is penetrated.

The Several Forms of Activity

Like the multiplication of the fundamental particles of physics, the known forms of activity of nerve cells have multiplied from a single one—the all-or-none impulse or spike—which was all that was known up to 1938. In that year Hodgkin, using the giant fiber of the squid, and very soon thereafter Katz, using the sciatic nerve of the frog, discovered the local potential, which can be graded and which spreads essentially passively—"electrotonically"—declining to half amplitude about every millimeter. Later work has shown several more kinds, the exact number depending on the distinctions one wishes to make.

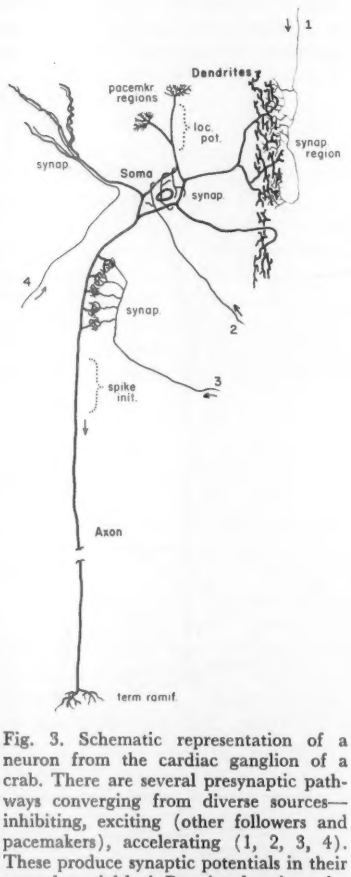


Fig. 3. Schematic representation of a neuron from the cardiac ganglion of a crab. There are several presynaptic pathways converging from diverse sources—inhibiting, exciting (other followers and pacemakers), accelerating (1, 2, 3, 4). These produce synaptic potentials in their several special loci. Restricted regions also initiate spontaneous activity ("pacemaker" regions, shown purely diagrammatically); local potentials (only labeled in one place but perhaps repeated elsewhere); and propagated impulses ("spike init.," also located arbitrarily). Only the axon supports all-or-none activity. Terminal ramifications are presumed to act by graded, local potentials. Integration occurs at each of the sites of confluence or transition from one event to the next. [Modified from Alexandrowicz (*13*)]

The scheme proposed in Fig. 4 indicates the relations between most of these. The first two, the *spike* potential and the *local* potential, are regarded as responses to antecedent activity within the same cell (when physiologically activated, not artificially stimulated); both are mediated by the local electric currents across the membrane as the result of the change in resistance of the already active regions and the standing "batteries" or electromotive forces between the two sides of the membrane. The one is regenerative, all-or-none, and propagated; the other is graded and decremental. In contrast, *generator* potentials of receptor neurons and *synaptic* potentials are responses of cells to impinging external events of specific kinds—sensory stimuli and junctional transmitters. There are two subdivisions of each of these categories based on the polarity of the response. On the basis of other differences, further subdivisions can be defined. There are also prepotentials resulting from no impinging environmental change but occurring under normal steady-state conditions and therefore properly called *spontaneous*. These can be manifested in more than one form: one is more or less sinusoidal (the time course is relatively independent of the occurrence of spikes); another is more or less saw-tooth-like (the time course is dependent on the intervention of a spike or local potential to reset the starting condition; a relaxation oscillation).

It is highly probable that some if not all of these different kinds of activity represent specialized kinds of cell surface membranes (*9*). This is suggested by the striking differences in properties and by the localization of each of these processes to restricted regions of the neuron. The circumscribed loci may recur at more than one site on the surface of a given neuron. Any one of the prepotentials is probably capable of causing spike initiation, at the restricted locus where this occurs, but commonly two or more prepotentials will act in sequence to this end. Perhaps any of the potentials can interact with any of the others to alter its rate of development or amplitude. But besides these sources of complexity a still more important source may prove to be the anatomical distribution of these different kinds of cell membrane over the neuron, their spatial separation, and the possibilities of interaction, of attenuation, and of invasion by the explosive all-or-none spike process. Only some regions of the cell are capable of supporting such a process, and perhaps it is just those which cannot support it that are most integrative.

Changes of State Not Visible in Potential

But this does not exhaust the list of separate processes within the neuron which contribute to the determination of firing. Besides the processes reflected in the membrane potential, there are others whose occurrence may give no sign in the membrane potential.

For example, many junctions manifest the property known as *facilitation*. This means that successively arriving impulses in the presynaptic pathway cause larger and larger synaptic potentials in the postsynaptic neuron. The excitability of the postsynaptic membrane may be said to have increased—although there may be no change whatever in the level of membrane potential after one synaptic potential has passed off and before the next has begun—from the corresponding level at an earlier stage, when the excitability was lower. Another junction upon the same neuron may under the same conditions manifest the opposite property, which may be called *diminution*; that is to say, successive responses are smaller (Fig. 5).

Aftereffects provide still other indications of differences in excitability not predictable from the membrane potential. Some cells under certain conditions continue to fire for a considerable time after the input has ceased; others show the opposite response—namely, a prompt rebound or overshooting return after input has ceased. Thus, if the response to the input is an increase in the level of activity, then there may occur after the cessation of this input a continued after-discharge—a maintained high level of activity for some time; or there may occur a rebound, which would mean in this case a period of decreased activity even below the previous background level. If on the other hand, the given

input has for its effect an inhibition of ongoing activity, upon its cessation there may continue for a period an afterinhibition, or there may occur a rebound increase in activity above the previous ongoing level.

Whereas the classical concept of the neuron has recognized the importance of excitability, this has been measured or thought of in terms of the spike threshold. The spike threshold is certainly important, although only at one point in the neuron—namely, the point where spikes are initiated. After this initiation has occurred, the spike excitability elsewhere is relatively unimportant, because the margin of safety is usually quite large for the activation of each successive point along the axon. What the newer knowledge has added is understanding that prior to initiation of the spike there are critical forms of excitability not measured by thresholds, because they determine the responses of subthreshold, graded and local events as a function of what came before them.

Spontaneity

Still further increasing the complexity of the combination of processes possible is the tendency to spontaneous activity in some neurons. By means of penetrating microelectrodes, spontaneity has now been examined from within in a number of cells—central neurons, receptors, and pacemakers of the heart. The observed voltages are enormously greater than in the usual arrangement of two electrodes outside the cell shunted by extracellular fluids, and this has permitted new insight into the intimate events that occur prior to each spontaneous discharge.

As a consequence, we can see the *continual change of state* at the subthreshold level, at least insofar as it is reflected in the potential of the cell body and nearby cell membrane (Fig. 6). We can infer also from the observations that the tendency to spontaneous change of state inheres in certain restricted regions of the neuron (the pacemaker loci), which influence the rest in turn indirectly. Furthermore, there is evidence that, at least in some neurons, more than one locus of spontaneity can exist at the same time in different parts of the cell, each with a different rate of change of state. The continual change of state of parts of the neuron under steady conditions of its environment may have significance not only in generating spontaneous activity but also in altering the responsiveness of the cell to any input impinging upon it. In addition, the spontaneous subthreshold potential changes of one neuron may influence other neurons, perhaps by electrotonic spread over short processes and perhaps by less specific mass field effects —for example, when many cells "beat" in unison, as in brain waves (*10*).

Conclusion

In sum, anatomically the neuron doctrine has never been more firm. The classical controversy gradually focused upon the issue of protoplasmic or neurofibrillar continuity between neurons. Today, while a number of exceptional cases of nerve cell syncytia are commonly ac-

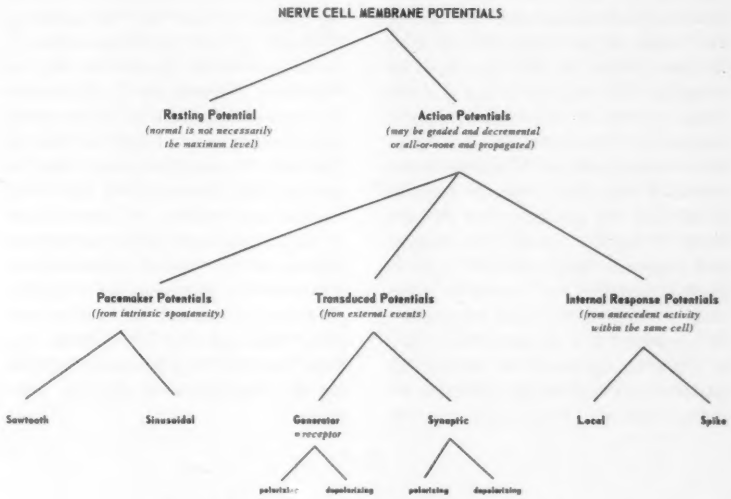


Fig. 4. The types of nerve cell membrane potentials.

Fig. 5. Facilitation and diminution. An ultramicroelectrode inside a nerve cell (of the cardiac ganglion of a lobster) recorded first the synaptic potentials resulting from a burst of five arriving impulses from one presynaptic pathway (from posterior small cells) and then those responding to a series of impulses arriving in another pathway (from the central nervous system). The former responses show diminution—the amplitude declines; the latter show facilitation—the amplitude grows. (Calibration, 100 msec, 21 mv.) [Courtesy of Dr. Carlo Terzuolo]

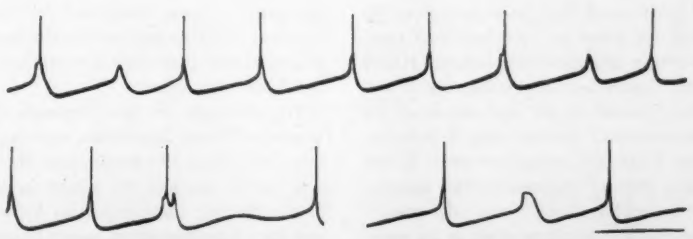


Fig. 6. Spontaneous activity in a ganglion cell as revealed by an electrode inside the soma (nerve cell body). The spikes are about 10 mv here (electrotonically spread from the axon) and are followed by a repolarization, then a gradual depolarization—the pacemaker potential, which at a critical level sets off a local potential. This, in turn, usually rises high enough to trigger a spike but is seen here several times by itself. Once (in the first half of the bottom row) the local potential fails to be set off. (Time, 0.5 second.) [Courtesy of Dr. Carlo Terzuolo]

cepted (for example, giant fibers of earthworm and squid), the weight of evidence from silver impregnation and, especially in recent years, from electron microscopy is against any such continuity. Physiologically, however, we have a new appreciation of the complexity-within-unity of the neuron. Like a person, it is truly a functional unit, but it is composed of parts of very different function not only with respect to metabolism and maintenance but also in the realms of processing diverse input and determining output—that is, of integration. The impulse is not the only form of nerve cell activity; excitation of one part of the neuron does not necessarily involve the whole neuron; many dendrites may not propagate impulses at all; and the synapse is not the only locus of selection, evaluation, fatigue, and persistent change. Several forms of graded activity—for example, pacemaker, synaptic, and local potentials—each confined to a circumscribed region or repeating regions of the neuron, can separately or sequentially integrate arriving events, with the history and milieu, to determine output in the restricted region where spikes are initiated. The size, number, and distribution over the neuron of these functionally differentiated regions and the labile coupling functions between the successive processes that eventually determine what information is transferred to the next neuron provide an enormous range of possible complexity within this single cellular unit.

In the face of this gradual but sweeping change in functional concepts, any statement but the most diffuse about expectations for the future must be very dangerous. Nevertheless I will venture to suggest that in the near future we will gain significant new insight at this unitary level of neurophysiology with respect to the functions and differentiations among dendrites, the chemical and perhaps ultramicroscopic specification of different kinds of surface membrane, additional labile processes, sites of possible persistent change, and the normal functional significance of intercellular reactions mediated by graded activity without the intervention of all-or-none impulses.

References and Notes

1. S. Ramon y Cajal, *Neuron Theory or Reticular Theory?* (Consejo Superior de Investigaciones Cientificas, Madrid, 1954), English translation.
2. A. T. Rasmussen, *Some Trends in Neuroanatomy* (Brown, Dubuque, Iowa, 1947).
3. For a complete bibliography, see S. Ramon y Cajal, *Recollections of My Life*; English translation by E. H. Craigie, *Mem. Am. Phil. Soc.* 8 (1937).
4. T. H. Bullock and C. A. Terzuolo, *J. Physiol. (London)* 138, 341 (1957).
5. F. Bremer, *Physiol. Revs.* 38, 357 (1958).
6. T. H. Bullock, *Revs. Modern Phys.*, in press; *Exptl. Cell Research* 5, suppl. 323 (1958).
7. G. Ling and R. W. Gerard, *J. Cellular Comp. Physiol.* 34, 383 (1949).
8. The study by Watanabe and Bullock was aided by a grant from the National Institute of Neurological Diseases and Blindness, National Institutes of Health, and by a contract (NR 101-454) between the Office of Naval Research, Department of the Navy, and the University of California.
9. H. Grundfest, *Physiol. Revs.* 37, 337 (1957).
10. See further: *Ciba Foundation Symposium, Neurological Basis of Behavior* (Churchill, London, 1958); J. C. Eccles, *The Physiology of Nerve Cells* (Johns Hopkins Press, Baltimore, Md., 1957); H. Fernandez-Moran and R. Brown, *Exptl. Cell Research* 5, suppl. (1958); A. Fessard, *Proc. Intern. Physiol. Congr. 20th Congr. Brussels* (1956).
11. B. Hanström, *Arkiv. Zool.* 16, 10 (1924).
12. S. Ramon y Cajal, *Histologie du Système Nerveux de l'Homme et des Vertébrés* (Maloine, Paris, 1909–11).
13. J. S. Alexandrowicz, *Quart J. Microscop. Sci.* 75, 182 (1932).

CURRENT PROBLEMS IN RESEARCH

Rock Magnetism

The magnetization of ancient rocks bears on the questions of polar wandering and continental drift.

S. K. Runcorn

Polar wandering, as a geological hypothesis, seems to have been first mentioned in correspondence between Halley and Hooke. It is interesting that it was then invoked as an explanation of the occurrence of marine fossils in sedimentary rocks well above sea level! In the early days of geology, Buffon and the "catastrophic school" were advocates of the shifting pole hypothesis as an essential element in the evolution of the earth's crust. Apparently Francis Bacon first suggested that continental drift had occurred when he noticed the similarity of the Atlantic coast lines of South Africa and South America.

Wegener gave the first thorough discussion of these hypotheses, opening a lively geological and geophysical discussion which reached its height in the 1920's. Of late, these important hypotheses have been discounted, partly because the geological data were complicated and by no means conclusively in favor of them and partly for the less legitimate reason that a tenable explanation of the supposed phenomena had not been put forward. Darwin's famous paper on polar wandering was thought to have disposed of the possibility. The suggested explanations of continental drift were shown by Jeffreys and others to be incompatible with the inferences successfully drawn by geophysists on the strength of the earth's interior. Yet Wegener's book, though dated, makes a strong case for continental drift. Later writers, such as Du Toit, amassed a great deal of information from structural geology and paleontology which, by its nature, could hardly appear decisive to the scientists in other fields and which perhaps unintentionally obscures some of the simpler and very persuasive reasons for serious consideration of continental drift. Moreover, these arguments are essentially qualitative, and their various presuppositions are open to criticism. They were therefore, perhaps unfortunately, not widely considered.

Recently, renewed interest in the problem of polar wandering and continental drift has resulted from paleomagnetic measurements. The directions of the permanent magnetization of certain sedimentary and igneous rocks of many ages from various parts of the world have now been determined. Most of the rocks studied have been well-bedded red sandstones

Dr. Runcorn is director of the department of physics, King's College, University of Durham, Newcastle upon Tyne, England.

and basaltic lavas. These rocks often possess a high degree of magnetic stability and have consistent directions of magnetization over considerable distances within one continent in any one geological period. Other rocks are known to be permanently magnetized, but have not yet been so extensively studied. Basaltic lavas are found to have a strong permanent magnetization (with intensity of 10^{-2} to 10^{-3} electromagnetic units); red sandstones, a less strong magnetization (with intensity of from 10^{-5} to 10^{-7} electromagnetic units). Except in Cenozoic times (the last 60 million years) these magnetizations are in different directions from the magnetization induced by the present geomagnetic field.

The possibility that the magnetization of rocks could be used in the investigation of polar wandering and continental drift has long been recognized. This follows from the supposition that the nondipole and equatorial dipole components of the geomagnetic field are oscillatory phenomena, and indeed changes in these components have been observed in recent centuries. This "geomagnetic secular variation" occurs because the field originates in the earth's fluid core (only a negligible amount arises from the ferromagnetism of the crust.) Averaged over periods of the order of the free-decay time of electric currents in the core (a few thousand years), the field is reasonably expected, on theoretical grounds, to be that of a dipole at the geocenter oriented along the axis of rotation. If, therefore, mean directions of magnetization of a rock series, based on samples sufficiently spread stratigraphically to eliminate the secular variation, are found to be different from the present mean field, there is a strong indication that those rocks were magnetized when they were in a different orientation with respect to, and at a different angular distance from, the axis of the earth's rotation at that particular geological time.

It is interesting to note that William Gilbert, who was unaware of the existence of secular variation when he published his great work *De Magnete* in 1600, concluded (*1*) that "unless there should be a great dissolution of a continent and a subsidence of the land such as there was of the region Atlantis of which Plato and the ancients tell, the variation (i.e. the declination) will continue perpetually immutable (in any one place)." As will be seen later, it appears that Gilbert's words were somewhat prophetic.

Physical Process of Magnetization of Lavas

The magnetic mineral in a basaltic lava is usually a member of the magnetite-ulvospinel solid-solution series. The Curie point of these is a maximum (575°C) for pure magnetite and decreases with increasing titanium content. The process of magnetization of a lava has been very carefully studied by reheating samples of lava in the laboratory in zero magnetic field until the Curie point is reached and then cooling them in fields of about ½ gauss, meanwhile observing the magnetic moment of the sample at different temperatures (see, for example, *2*). In principle, the process by which magnetization is acquired on cooling is now well understood, from the standpoint of both experiment and theory. Normally, the coercive force and the intensity of magnetization decrease with temperature, the decrease being particularly rapid just below the Curie point. Consequently, in the presence of the geomagnetic field, the lava becomes strongly magnetized as it cools below the Curie point when its coercive force is low. On cooling to ordinary temperature, the coercive force rises to about 50 gauss, and subsequent changes in the direction of the geomagnetic field have no further influence on the magnetization.

In some cases, however, the magnetization of the iron-oxide minerals is anomalous. Nagata (*3*) has found and carefully studied a pumice which becomes magnetized in a direction opposite to the field in which it cools, thus verifying a remarkable prediction made by Néel (*4*). This process occurs because the magnetic minerals are tiny intergrowths of two ferri-ilmenites. The component of higher Curie point becomes magnetized first as the pumice cools, but when the Curie point of the other component is reached, the geomagnetic field within the mineral has been overwhelmed by a field in the opposite direction due to the magnetization of the former component. Under certain conditions the "reversed magnetization" of the second component may outweigh the

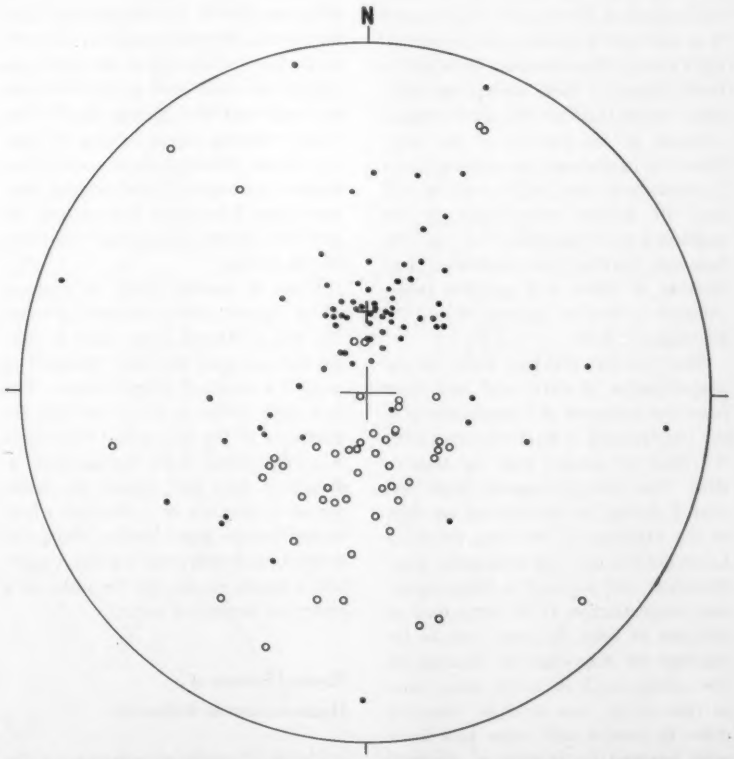


Fig. 1. Directions of magnetization of Columbia River lavas: (solid circle) plotted on lower hemisphere; (open circle) plotted on upper hemisphere. (Cross) Field direction corresponding to geocentric dipole along present geographical axis. [From measurements in C. D. Campbell and S. K. Runcorn, *J. Geophys. Research* 61, 449 (1956)]

first. Such intergrowths are a common feature of the iron-oxide minerals in rocks, and so, although no other example of the phenomenon discovered by Nagata has yet been found in lavas, it has been held that similar processes are responsible for natural magnetizations with polarities opposite to that of the present geomatic field. Such reversals have been found in the Tertiary lavas of the Columbia River plateau (Fig. 1), Iceland, Japan, and the Central Massif of France. They are also common in sediments and occur at all times in the geological column, though apparently with varying frequencies. The alternative explanation of these widespread reversals of magnetization throughout the geological column is, of course, that the geomagnetic field has, every few millions of years, reversed its polarity.

The fact that Tertiary lavas, when examined today, have not been found to possess the self-reversal property which Nagata discovered cannot be held to exclude completely the possibility that they did not possess this property at the time of their cooling and magnetization, for slow changes take place in the iron oxide minerals with time. However, the natural occurrence of reversed magnetization is so widespread that it would be exceedingly strange if reversals are to be attributed mainly to these anomalous processes rather than to real and frequent reversals of the polarity of the field. However, nature can, on occasion, cover its tracks very well, and it may be said that the decisive experiment on this problem is yet to be performed. One test, however, has now been made in a large number of cases, and provides strong evidence in favor of real reversals of the geomagnetic field.

Many workers who have measured the magnetization of dykes and lava flows have also measured the magnetization of the country rock at small distances from the point of contact with the lava or dyke. The sampled country rock was heated, during the intrusion of the dyke or the extrusion of the lava, above its Curie point and so lost its original magnetization and acquired a thermoremanent magnetization at the same time as the lava or dyke. In every case so far reported the magnetization acquired by the country rock is in the same sense as that of the lava or dyke. Cases of dykes in contact with older lava flows were reported by Hospers in the lava flows in Iceland. Cases of lavas in contact with underlying sediments which were baked red were reported by Roche in the Central Massif of France and by Opdyke and Runcorn (*5*) in the lava fields near Flagstaff, Arizona. If it is supposed that reversals of the geomagnetic field do not occur and that the reversed magnetizations which are observed in approximately 50 percent of Cenozoic lavas are due to the self-reversal property of the iron oxide minerals they contain, then one should, in about 50 percent of the cases studied, find the country rock and the igneous rock which bakes it having magnetizations in opposite senses. Although these contact-zone observations require further careful documentation, I feel that they exclude the possibility of any widespread "self-reversal" in nature.

There is another piece of evidence which bears on this question of reversal. No lava of Recent times (that is, since the last ice age) has been observed to acquire a reversed magnetization. This fact again seems to me to exclude the possibility of the widespread occurrence of a self-reversal of the Nagata type, although it does not exclude the widespread occurrence of a reversal which occurs through slow chemical change or through exsolution processes which might take a length of time of the order of a geological period to occur.

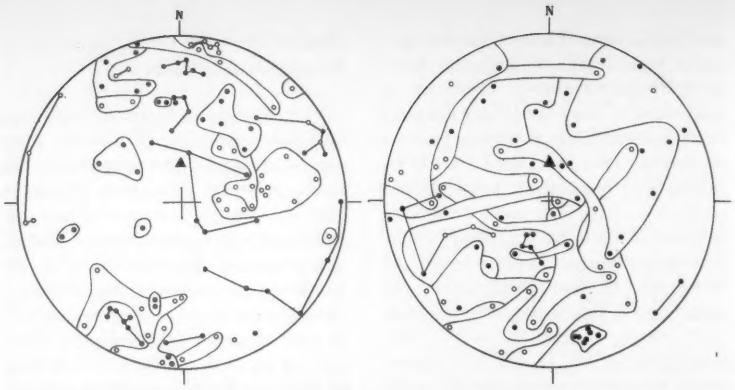


Fig. 2. Directions of magnetization in 47 conglomerate pebbles. (Left) Very fine sandstone pebbles with small internal dispersion; (right) fine, medium, and coarse sandstone pebbles with large internal dispersion. Lines enclose pebbles of definite New Red Sandstone age which have the same direction of magnetization and link together pebbles of presumed New Red Sandstone age which have the same direction of magnetization. Plane of projection is the horizontal. [From D. W. Collinson, K. M. Creer, E. Irving, S. K. Runcorn, *Phil. Trans. Roy. Soc. London* **250**, 83 (1957)]

Physical Process of Magnetization of Sediments

The first careful examination of the magnetization of sediments was made on the varved clays of New England and Sweden, which have been deposited in glacial lakes in the last several thousand years. There seems little doubt that the remanent magnetization of these clays arises from the magnetic orientation of the iron oxide grains, which retain some of the magnetization originally acquired in the igneous rocks from which the clays were derived by erosion. The varved clays may easily be dispersed and redeposited in the laboratory under magnetic fields of various strengths and orientations, and it has been proved by Johnson, Murphy, and Torreson (*6*) and by Griffiths and King (*7*) that the clays become magnetized roughly in the direction of the field but with an "inclination error." This error arises from the tendency of the elongated or discoidal grains to lie parallel to the bottom. Since the particles will usually be magnetized along a long axis, the permanent magnetization of the clay has a lower angle of magnetic inclination than the field in which the particles are deposited. Griffiths and King have also shown that currents in the water may affect the direction in which the elongated particles settle and hence may affect the direction of acquired magnetization.

However, the study of varved clays has only limited application in paleomagnetic studies, for these clays are of very infrequent occurrence in the geological column, and it is unwise to infer from these studies the process by which other sediments, particularly red sandstones, acquired their magnetization. Laboratory experiments have only limited application to this subject, as it is impossible to infer or to reproduce exactly the physical and chemical conditions in which rock is laid down. It is

possible that the remanent magnetization of varves may give a more correct value for the direction of the field at the time of magnetization than the laboratory experiments suggest, for it has been shown experimentally that, even after deposition, the water in the pores between the grains of the sediment enables the denser and smaller iron oxide grains to rotate in the direction of the field, and this process would appear not to be subject to the two causes of misalignment described above. As the varves are the only deposits showing annual layers, they would appear to be ideal for the careful study of the short-term changes of the earth's magnetic field, known as the secular variation.

By far the most widely studied of other sediments are the red sandstones and shales; it is an observed fact that red sandstones and shales are frequently much more strongly magnetized than other sediments and can very often be shown to possess "magnetic stability." By this is meant that they acquired a permanent magnetization early in their geological history and have retained it unaltered (at least within a few degrees) since. This important fact has been determined by the use of a "field" test of stability, first suggested by Graham (*8*). By finding pebbles in a conglomerate bed which were derived from the rock formation under study and determining the directions of magnetization which they have at present, information about the stability of the rock since the conglomerate bed was formed can be obtained. For example, in Fig. 2 pebbles of Torridonian (late Precambrian) sandstone in a Triassic conglomerate are seen to have directions of magnetization in random directions in space, as they must have had when the conglomerate was formed. This is evidence that the Torridonian sandstone has had magnetic stability over the last 150 million years. Similarly, folded or tilted beds which have directions of magnetization which agree with those of flat-lying beds of the same geological formation elsewhere only after allowance has been made for the geological dip, must have been magnetically stable since the tectonic movements took place. Had the original magnetization acquired when the beds were formed been unstable and a new magnetization been imposed by some agency after the rocks had attained their new positions, then the present directions of the magnetizations of the various samples would be more nearly parallel.

Even when the red sandstones are not completely magnetically stable, the instability often takes a simple form: The rocks acquire a component, of intensity varying from specimen to specimen, directed along the mean geomagnetic field in recent times, which is known to be that of a dipole orientated along the present axis of rotation of the earth. Thus, the resultant directions of magnetization of samples from such a formation form a streak, rather than a well-grouped set, in a plane containing the present "dipole" direction and the direction of the field at the time of the formation of the rocks. Some information about the latter direction can therefore be obtained even from unstable rocks. An example is shown in Fig. 3. The cause of such a magnetization has not yet been established, although it is known that iron oxide minerals of a certain grain size cannot retain magnetization for long periods, and presumably an appreciable component of iron oxide of the critical grain size is present in some samples of the sediments. Such grains would slowly pick up a magnetization from the ambient magnetic field and so produce the above-mentioned effect.

The comparative magnetic stability of the red sandstones can reasonably be ascribed to the high coercive force (many thousands of gauss) of the hematite grains which they contain. The small grains forming the red coating of the quartz grains, of which the sandstones are mainly composed, and the black detrital iron oxide grains, which are usually present to the extent of about 1 percent of the whole rock, are usually found to be hematite. Miller and Folk

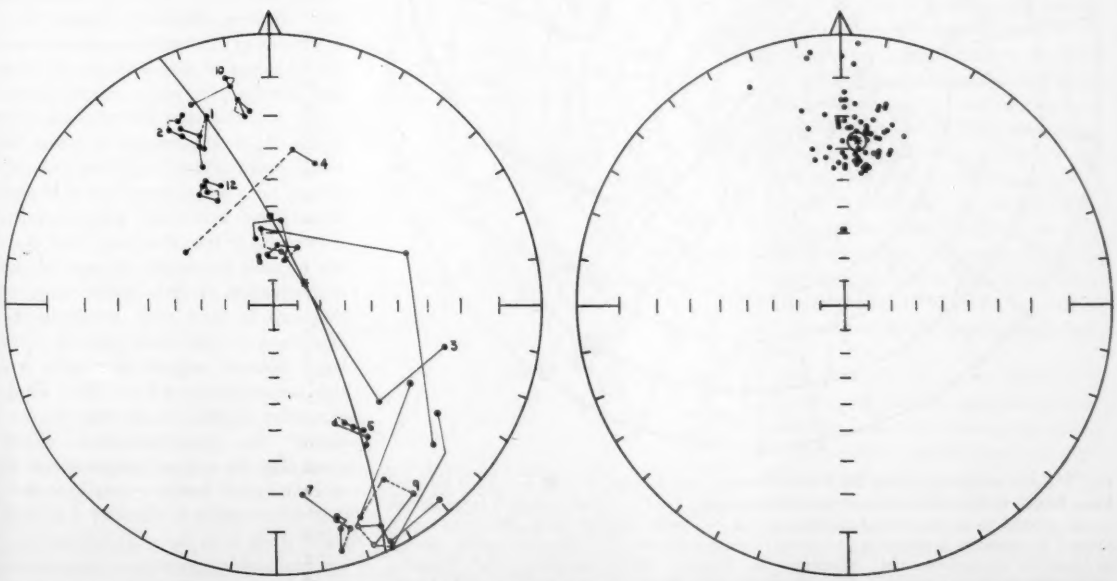


Fig. 3 (left). Streaking in Chinle formation (Upper Triassic) from Moab, Utah. Solid square indicates present dipole field. Solid line and solid circles are on the lower hemispheres of the projection; dashed line and open circles are on the upper hemispheres of the projection. Fig. 4 (right). Magnetic directions in Triassic beds, Frenchtown, New Jersey. Solid square indicates present dipole field. Solid circles lie on the lower hemispheres of the projection; open circles lie on the upper hemispheres of the projection.

(9) point out that red beds, in contrast to grey-green and white sediments, usually contain abundant detrital iron oxides, but they incorrectly describe these black detrital grains as magnetite and ilmenite. It is not known which component carries the remanent magnetization, and it is likely that in some rocks it is the coating and, in some, the detrital minerals. It has, however, been shown by laboratory experiments that the crystallization of hematite from iron hydroxide soaking into a pure quartz sand in the earth's magnetic field leaves the sample permanently magnetized in the direction of the geomagnetic field. This phenomenon, called "chemical magnetization," deserves further study, but it seems reasonable to assume that, in the course of a chemical change producing a ferromagnetic mineral (even at ordinary temperature) the iron ions will become free to turn into the direction of a weak field and that, on the completion of the chemical change, the material will remain permanently magnetized unless it is exposed to a field of very much greater intensity. Another possibility is that the hematite grain grows beyond a critical size below which it has a very low coercive force but above which it is very stable. Such a process is suggested by Néel's theory of the magnetization of single-domain grains (*10*). The directions of magnetization of sediments which acquired their magnetization in this way would not, of course, be expected to possess inclination error.

It has been mentioned that the commonest recognizable form of magnetization acquired by rocks since deposition is magnetization directed along the earth's present field, and one possible mechanism by which this is obtained has been described. Such magnetization is not uncommon in rocks now exposed in the southwestern United States, and it is also possible that it is a recent chemical magnetization. In a hot climate in which there are at times heavy rains, it is possible that in the surface layers some of the hematite becomes hydrolyzed. Later on, the hydroxide formed decomposes to hematite again, which then picks up a magnetization parallel to the present field. This process would be expected to be particularly important in porous sediments.

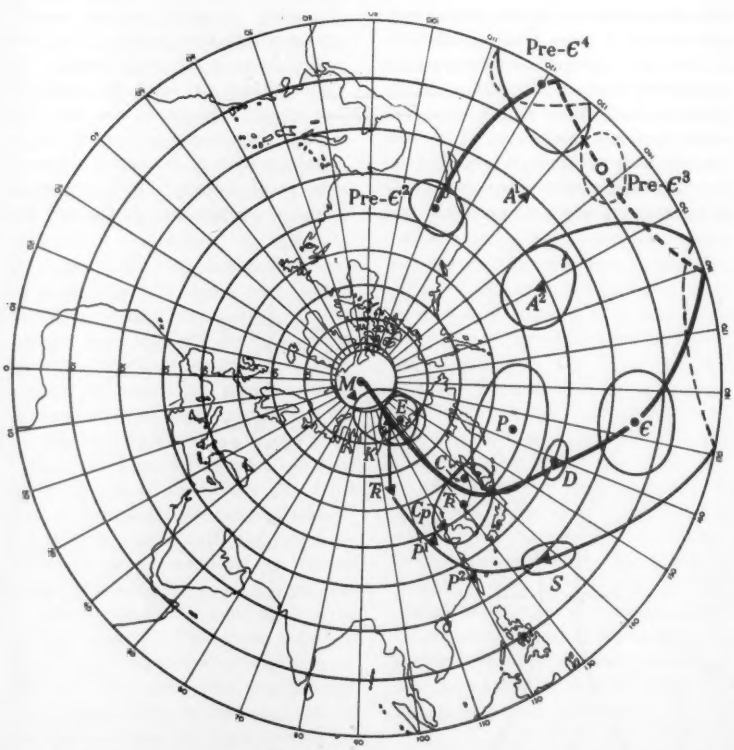


Fig. 5. Polar wandering paths for North America and Europe. (— ● —) Path inferred from British rocks, plotted in northern hemisphere; (- - ○ - -) path inferred from British rocks, plotted in southern hemisphere; (— ▲ —) path inferred from American rocks, plotted in northern hemisphere; (- - - - - - -) path inferred from American rocks, plotted in southern hemisphere. (M) Miocene; (E) Eocene; (K) Cretaceous; (T_R) Triassic; (P) Permian; (C_p) Cambrian, Pennsylvanian; (D) Devonian; (S) Silurian; (O) Ordovician; (ε) Cambrian. (A) Algonkian (late Precambrian of the United States): (A^1) Hakatai shales (Doell's measurements); (A^2) Hakatai (south rim of Grand Canyon). (Pre-ε) Late Precambrian of Great Britain: (Pre-ε^2) lower Torridonian; (Pre-ε^3) Langmyndian; (Pre-ε^4) Upper Torridonian.

Other Sources of Secondary Magnetization

In the early days of study of rock magnetism, any anomalous magnetizations found in rocks were usually ascribed to very special causes (see *11*), as it had not then been understood that rock formations usually possess a reasonably uniform magnetization over considerable areas. Lightning, in particular, was cited as a source of magnetizations in rocks, and effects of this kind were demonstrated by placing lava samples around the bottom of lightning conductors. There seems little doubt that lavas in exposed positions may get strong, but very localized, magnetizations in this way, though sufficient studies do not seem to have been made of such anomalies.

Recently the effect of mechanical stress on the direction of remanent magnetization has been discussed. Graham (*12*) has shown by laboratory experiments that the direction of magnetization of lavas and metamorphic rocks changes appreciably under uniaxial stresses of an order which might be produced by burial beneath some thousands of feet of rock. Although he is not able to show that such effects have irreversible characteristics, it is probably true that, over long periods of time, irreversible changes in the magnetization of rocks might occur in this way. In some rock formations the agreement in the fault patterns over large distances suggests that stress systems are more than a local effect. Thus, it appears desirable to entertain the possibility that magnetostriction effects could alter the original magnetization of rocks in such a confusing way as to prevent the remanent magnetization of rocks under study from throwing light on major geophysical problems. This indeed seems to be what Graham suggests.

However, although laboratory experiments suggest ways in which the magnetization of rocks could be produced

at or after deposition and could later be altered, deductions from them have little direct relevance to the interpretation of the remanent magnetization of rocks. This is a surprising point of view only to those who imagine that the physics of the processes by which rocks are formed and the history of the rocks are known in quantitative detail.

There will be those who hold that if this is true we might as well abandon the subject; however, this does not seem to be the way the scientist works—he tries to make sense of those observations of the physical world which can be made. Therefore, while laboratory experiments on the magnetic properties of rocks are interesting for their own sake and need to be pursued extensively, carefully analyzed field measurements are more likely to reveal how any particular rock formation became magnetized.

Results of Paleomagnetic Surveys

A typical example of a well-grouped set of paleomagnetic directions is given in Fig. 4. Some of the scatter may represent the effect of the wobbling of the geomagnetic field about its mean position over the period of time represented by the rock series. The mean direction of such a set of measurements is assumed to correspond to the field which would be produced at that place by a geocentric dipole oriented along the earth's axis of rotation at that time. A simple formula of spherical trigonometry makes it possible to calculate the position of the poles for that geological time on the present globe, that is, assuming for the moment that the present distribution of the continents has remained unchanged.

In the last few years there has been a very rapid increase in the accumulation of paleomagnetic data. The initial aim has been to trace in outline the changes in the earth's magnetic field throughout geological time, as determined by rocks from different continents. For this purpose the sampling has been restricted in certain ways:

1) Study has so far been restricted to rather strongly magnetized rocks. Because initial surveys showed that, in general, among igneous rocks, lavas, and, among sediments, red sandstones, are most strongly magnetized, the study has largely been restricted to these. It is not known that weakly magnetized rocks are intrinsically less useful for purposes of this study, but strongly magnetized rocks can be more easily measured, and consequently changes in their magnetization in the course of the laboratory processes can be more easily observed.

2) The main sampling has been carried out in those areas where very little tectonic movement has occurred, on the grounds that stress and rise of temperature might irreversibly affect the original direction of magnetization.

3) Surveys throughout the geological column have been made, rather than very extensive collections of rocks from one particular period, although certain rock series, such as the Torridonian sandstone, have been studied in great detail.

In the interpretation of paleomagnetic data it has been assumed, on the basis of theory, that the geomagnetic field, when averaged over some thousands of years, is a dipole directed along the axis of rotation. This theory has experimental support in that it accords with paleomagnetic observations for late Tertiary and Quaternary times in different areas of the world. Collections of samples from rock formations selected in the way described above have been measured on an astatic magnetometer, and their directions of magnetization have been checked in some cases with a spinner magnetometer.

We have taken steps to eliminate, or allow for, the effect of magnetization acquired in recent times along the present direction of the earth's magnetic field. Where possible, the field tests of stability of magnetization of folded beds and conglomerates have been used. A degree of stability is invariably found in such rocks. In the vast majority of cases a geological formation gives a well-grouped set of directions of magnetization, from which the mean can be calculated. The mean has been designated as being the direc-

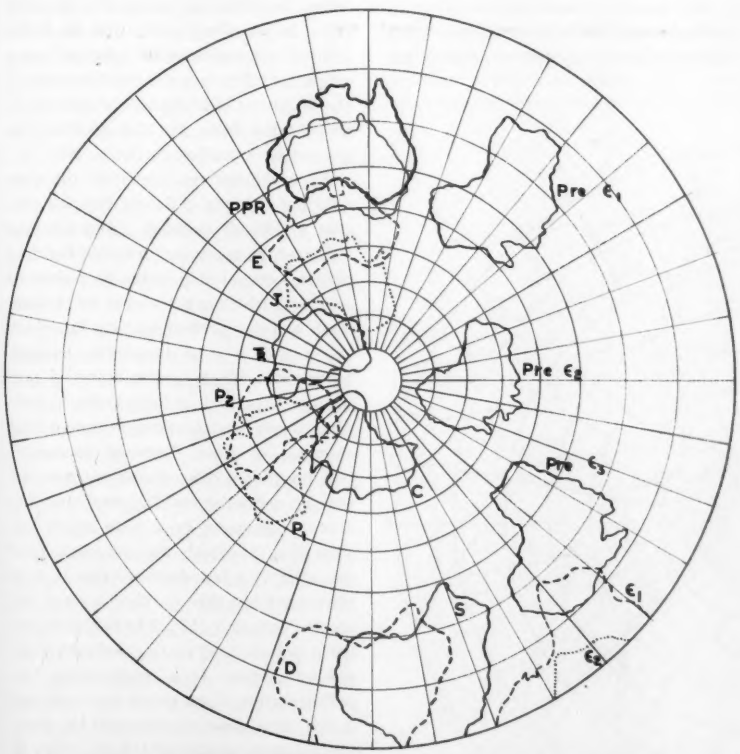


Fig. 6. Stereographic projection showing position of Australia relative to the pole. (PPR) Pliocene, Pleistocene, and Recent (newer volcanics of Victoria); (E) Lower Tertiary, probably Eocene (older volcanics of Victoria); (J) Mesozoic, probably Jurassic (Dolerite sills of Tasmania); (T_R) Triassic, probably lower Triassic (Brisbane tuff); (P_2) Permian, Upper Marine Series (volcanics of Illawarra coast); (P_1) Permian, Lower Marine Series (volcanics of Hunter Valley); (C) Upper Carboniferous (Kuttung red varvoid sediments and Kuttung lavas); (D) Devonian, probably Lower Devonian (Ainslie volcanics); (S) Upper Silurian (Mugga porphyry); (ϵ_2) Middle Cambrian (Elder Mountain sandstone); (ϵ_1) Lower Cambrian (Antrim plateau basalts); (Pre-ϵ_3) Top of Upper Proterozoic (Buldiva quartzite); (Pre-ϵ_2) Upper Proterozoic (Mallagine lavas); (Pre-ϵ_1) lower part of Upper Proterozoic (Edith River volcanics).

tion of the magnetic field of a given geological period (or part of a period) minus the effect of the geomagnetic secular variation. The pole position calculated from this direction and from the present geographical latitude and longitude of the site is not only the mean magnetic pole for that period of time but is assumed to be the pole of rotation of the earth relative to the continent in question.

From Precambrian times to the present, pole positions have been determined relative to Great Britain, North America, and Australia (Figs. 5 and 6). The following features of these pole positions, or "polar wandering curves," as they are called, have been found:

1) Pole positions of successive geological periods lie on a reasonably smooth curve, and they lie successively nearer the present pole as their age diminishes.

2) The curves drawn through these pole positions for the two continents of Europe and North America are of roughly similar shape, whereas that for Australia is different.

3) There is systematic displacement between the curves for Europe and North America which has been interpreted by Runcorn (*13*) as showing that, after Triassic times, a relative motion of North America and Europe took place. It is not by any means easy to be specific about the value of this displacement, but estimates range from a value of about 24° (see Figs. 7 and 8) to 45° (see *14*).

4) Results obtained in Australia (*15*), South America (*16*), and South Africa (*17*) lead one to suppose that a very considerable amount of continental drift occurred in the Southern Hemisphere in Mesozoic times.

Statistical Methods in Measuring Rock Magnetism

It is, perhaps, at first sight surprising that measurements of the paleomagnetic directions of, say, a dozen samples from a rock formation hundreds of feet thick and covering hundreds of square miles may provide an adequate estimate of the direction of the earth's field during the epoch in which these rocks were laid down. To the geologist a rock formation is a series of rocks, whose lithological character enables them to be traced and, in consequence, mapped, over a considerable area of country. The rocks comprising the formation will be laid down in similar environments or in a series of alternating environments. A formation usually spans a fraction of a geological period—perhaps some million years. In the case of basaltic lava flows, a single flow may be traced over many tens of miles, over which its thickness remains remarkably constant. Therefore it must have flowed out, solidified, and cooled below the Curie point within a few months. Consequently, in a single flow one might expect the lava to record the direction of the earth's field at a point of time. The flow lying upon it will likewise provide a record of the value for the field at another point of time, perhaps many hundreds or thousands of years later. In practice it seems that the directions of magnetization of samples from a single lava flow are scattered because of the magnetic disturbances produced by neighboring flows, but this problem has not yet been studied carefully.

In a sedimentary formation the time relations between different samples present a difficult problem. Commonly, a sediment possesses innumerable bedding planes, recognizable today as planes of weakness which are revealed by erosion. Such planes represent surfaces on which the rate or type of deposition changed, or down to which erosion removed previously deposited sediment. Such bedding planes may therefore represent long intervals of time. Between successive bedding planes the sedimentary material may be deposited rapidly; these may become magnetized in a time much less than that in which the magnetic field can alter by a few degrees—that is, in a time much less than the time scale of the secular variation (*18*). Further, in lacustrine, deltaic, and marine sediments deposited offshore in a transgressing sea, sedimentation is not continuous over the entire area now represented by these rocks. Consequently the sediments are in the form of wedges, which disappear when traced laterally. Similarly, the bottom and top of a sedimentary formation at one place will not represent the same time-span as analogous horizons of the same rock formation in a different place; a time line running through the formation will therefore, in general, make an angle with the bedding planes.

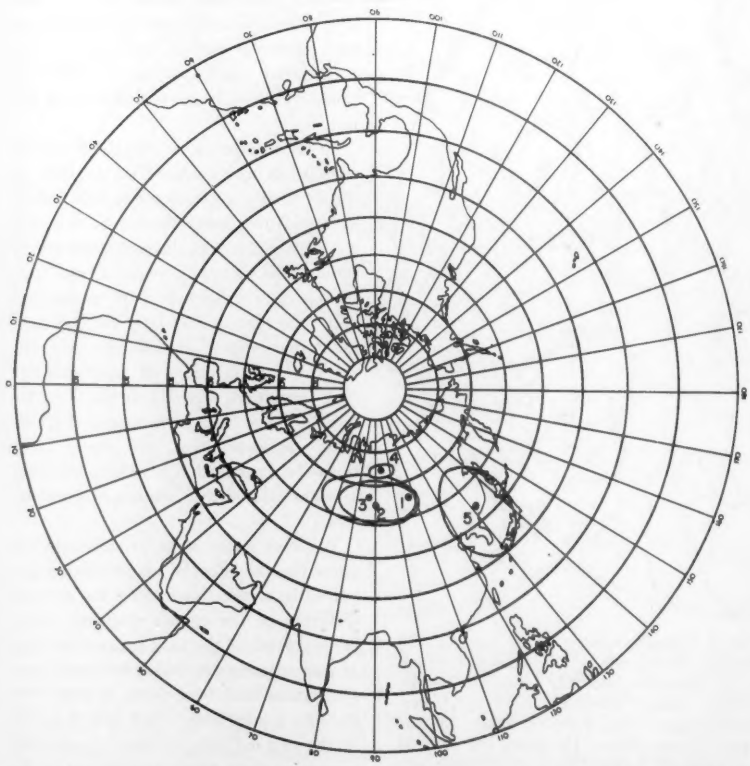


Fig. 7. Upper Triassic pole positions for the United States and Great Britain. (1) Springdale sandstone, Utah; (2) lavas near Holyoke, Massachusetts; (3) lavas and sediments of Connecticut; (4) Newmark series, New Jersey; (5) Keuper marls, England. [P. M. du Bois, E. Irving, N. D. Opdyke, S. K. Runcorn, M. Banks, *Nature* **180**, 1186 (1957)]

The above theory therefore suggests that if samples are selected from different horizons spanning a considerable thickness of the formation, the mean direction should effectively average out the secular variation and any deviations due to polar wandering during the time represented by the formation.

It is found that the directions of such samples are scattered randomly about a mean direction, and Fisher (*19*) has suggested that the relative frequency of directions at an angle θ with this mean is given by $e^{K\cos\theta}$, where K is a measure of the precision. If each of the N directions is represented by a unit vector, then the magnitude of the vector sum R will be much less than N if there is great scatter and will be nearly equal to N in the case of a close grouping of directions. Fisher shows that an estimate of K is provided by $(N-1)/(N-R)$ and that the best estimate of the mean direction is the vector mean. I have given the approximate formula that 63 percent of the directions make an angle with the mean direction of less than $81/\sqrt{K}$ degrees (*18*). I have also shown that the angular radius of the cone of confidence which, described about the calculated mean direction, includes the true mean direction with a probability of 95 percent equals approximately $140/\sqrt{KN}$ in degrees. It can therefore be readily seen that if K is 100, 63 percent of the directions lie within a cone of semiangle of 8° described about the vector mean direction, and the angle of the cone of confidence can be reduced to within 5° by taking about ten samples.

Just as there are local magnetic anomalies on the earth's surface today which alter the direction of the geomagnetic field (for example, at Kursk, U.S.S.R.), so there will undoubtedly be found anomalous paleomagnetic directions.

It may be asked whether it is possible to show that over very considerable areas the direction of the magnetic field deduced from the paleomagnetic measurements is consistent. There are not yet as many measurements relating to this point as one would like. But almost every rock formation which has been studied extends over hundreds of miles, and there is certainly consistency in the paleomagnetic directions to this extent. It is much more interesting, however, to consider whether the paleomagnetic measurements of rock formations of the same age across an entire continent give poles which are in the same place. In this connection it must be noted that the polar-wandering curve indicates a mean movement of the pole of about one-third of a degree per million years, and consequently it is quite possible that, during a geological period, the polar motion (apart from the secular variation which is assumed to be smoothed out in all cases) could lead to discrepancies of up to 20 or 30 degrees in the paleomagnetic directions of rocks of the same geological period. Unfortunately the rocks which have been used so far in studies of paleomagnetism are, of course, those in which fossils are most scarce, and consequently the determination of the geological age to any accuracy very much shorter than a geological period seems rather difficult. However, the Upper Triassic of the United States furnishes an example of the good agreement between pole positions from widely different areas, as is shown in Fig. 7.

Paleowind Directions

For independent evidence of polar wandering, recourse must be had to the evidence of paleoclimatology. The methods geologists have used in such investigations are not quantitative and are open to various objections. It is of interest to consider whether there are more physical methods of determining the latitude and orientation with respect to the axis of rotation of land masses at different geological times.

The explanation of the deflection to the east of the winds blowing toward the equator in the trade-wind zones was given long ago by Hadley and concerns the deflecting action of the Coriolis force on air drawn to the equator. Consequently, it is probable that through geological time there has always been a trade-wind belt, although its extent in latitude may have altered. Recently, Opdyke and Runcorn (*20*) have examined the question of whether the winds in ancient geological time were appropriately orientated relative to the equator of that time. That the direction of the wind which transported sand in the accumulation of certain aeolian deposits may be determined by measurements of the direction of the line of greatest dip in cross-laminated rocks is a theory that has been developed by Reiche (*21*) and Shotton (*22*). These

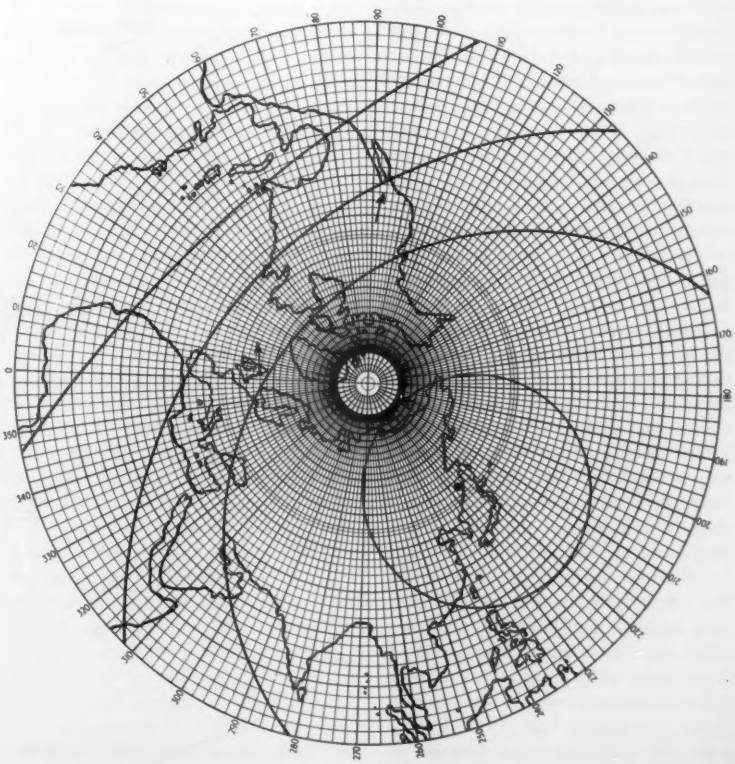


Fig. 8. Wind directions and equator for Paleozoic times. Solid circle, Carboniferous pole position; arrows, paleowind directions in Permocarboniferous times.

authors showed that the Coconino sandstone of Arizona and the New Red Sandstone of Great Britain represent the accumulation of many crescentic or barchan dunes, traces of the lee slopes of which are revealed in exposures of these rocks as cross laminations of large size. Modern barchan dunes have been carefully studied by Bagnold in the Libyan Desert and by many other workers. Steady wind blows sand up the gently sloping windward side of the dune, the sand falling on the lee slope at its angle of repose, about 32½°. The laminations of the lee slope are consequently protected from erosion, and apparently may be preserved (perhaps truncated) if the dune sea consolidates into rock.

The crescentic shape of the dune causes the directions of the line of greatest dip of the cross lamination to be spread over about a right angle, so that the wind direction at one locality is the mean of these directions obtained from a number of cross-laminated units, each of which represents a different part of the dune.

Cross laminations can arise from deposition in rivers and in beach deposits but are usually of smaller scale. There is, however, no single criterion which permits classification of a cross-bedded sandstone as aeolian or not aeolian (*23*). Opdyke and Runcorn (*20*) show that certain parts of the Tensleep, Casper, and Weber sandstones, of Wyoming and Utah, of Pennsylvanian age are likely to be aeolian. They show that the wind which deposited these sandstones came from the northeast quadrant, as is true also in the case of the Coconino sandstone of similar late Paleozoic age, studied by Reiche (*21*). The consistency of these wind directions over a large area is shown in Fig. 9.

It is, of course, true that the wind today is affected by topography, the planetary wind system being considerably distorted in certain areas. The consistency of the wind directions described above, however, indicates that this wind is probably a planetary wind and not one affected decisively by local geography. It must be remembered that the present time is one of unusually high relief, and it may be that the planetary wind system was less distorted in remote geological time. Again, it must be remembered that a rock series represents a long period of time during which local effects may be expected to average out, to some extent. There is an analogy here with rock magnetism, in which the mean direction of magnetization of a geological period apparently averages out the nondipole parts of the geomagnetic field which are of importance at any one instant of time.

It will probably not be possible to map the directions of the ancient winds in the detail in which the ancient magnetic field can be mapped, unless some method apart from the study of aeolian sandstones, which appear to occur infrequently in the geological column, can be found. But it is interesting to see from Fig. 8 how the late Paleozoic wind directions of North America and Great Britain fit in as the northeast trade winds relative to the late Paleozoic equator, derived from paleomagnetic studies.

Geological Evidence of Paleoclimates

The traditional method of inferring the climates of a geological period depends on the type of sediment and on the fossil record. It cannot be said that most of the evidence is of a type which can be interpreted unambiguously. For an exploratory comparison of the paleomagnetic and paleoclimatic evidence, we use two of the least disputable inferences from the geological record.

1) Evidence of glaciation over considerable areas in Permocarboniferous times has been found in Australia, South Af-

Fig. 9. Paleowind directions.

rica, South America, and India. Unless there has been radical change in the climate of the globe as a whole, we can infer that such glaciations were restricted to the then polar regions. Simpson (*24*) suggests that extensive sea-level glaciation could not have occurred at latitudes of less than about 50°. The paleomagnetic observations show that Australia was in high latitudes in Permocarboniferous times and also in late Precambrian times when there is also evidence of glaciation in Australia. Paleomagnetic surveys of South Africa, South America, and India for Permocarboniferous times are of key importance.

2) Occurrence of extensive red beds suggests either a hot, humid or a hot, arid climate. It is difficult to see how such conditions could occur except near the equator if the axis of rotation of the earth is nearly perpendicular to the ecliptic. Similarly, dune sandstones and evaporites indicate a position close to the equator. Abundant beds of the type described are typical of northern Europe and Great Britain from the Devonian to the Triassic, of western United States between Pennsylvanian and Jurassic times, and of eastern United States between the Silurian and Triassic. The paleomagnetic determinations put Great Britain and the United States in low latitudes during Paleozoic and early Mesozoic times. Dividing the values of the paleomagnetic angles of inclination less than about 30° by 2 gives the corresponding latitudes quite accurately (*25*).

Hypothesis of Polar Wandering

The evidence of paleomagnetism, with which that of paleoclimates does not conflict, suggests that the poles of rotation of the earth and the land masses have gradually changed their relative positions. We must therefore briefly consider the mechanism by which polar wandering and continental drift could have been brought about. The latter involves more degrees of freedom than the former, but, fundamentally, both require that the earth be able to flow if subjected to steady stresses over millions of years, and both require that there be internal movements of some kind. Recently the mechanics of polar wandering has been discussed in outline. Clearly, what is required is that if the axis of figure of the earth is displaced from the axis of rotation by an infinitesimal amount, the stresses due to the centrifugal forces will cause the earth to flow so that the equatorial bulge will return to a plane perpendicular to the new axis of rotation. The time constant of this process appears to be between a few hundred thousand years and a few million years. The physical cause which displaces the two axes in the first place is a matter for conjecture. Random disturbances in the crust or processes in the mantle are possibilities. Mountain building and convection currents in the mantle have been shown to be adequate causes. It should perhaps be emphasized that no change in the direction of the axis of rotation in space, that is, no change in the angular momentum of the earth, is involved in these processes.

Hypothesis of Continental Displacements

Probably most geologists and geophysicists feel reluctant to admit the possibility of relative displacements of the continental masses in the recent history of the earth. It is often stated that a sound reason for such skepticism is the absence of any adequate theory of the mechanism by which such continental displacement could have taken place. This is an argument which should not be given much weight. Not until the last few years has there been an adequate theory for the existence of the geomagnetic field, but scientists did not previously disbelieve in the existence of the field for this reason.

That the coast line of much of South Africa and South America fits together is of course a fact which the exponents of continental drift have thought very significant. Jeffreys' (*26*) statement that the fit is a poor one has recently been shown to be untrue by Carey (*27*). It is significant also that the mid-Atlantic ridge follows a line parallel to these two coast lines.

It is perhaps significant that the continental displacements of thousands of miles since the late Mesozoic represent an annual rate of movement of the same order as that occurring along the San Andreas fault (*28*). By geodetic observations this has been determined to be 1 centimeter per year at the present time. Geological correlation suggests that there has been a displacement of possibly 350 miles in 100 million years, or 0.6 centimeter per year. The existence of this relative motion in the earth's crust today implies that movements deeper in the crust are taking place for which we have no adequate theory. We have no means of knowing whether such movements are capable of causing relative movements of larger areas of continental material.

Perhaps thermal convection in the mantle is occurring, and this may be the explanation of continental drift. It is well known that the present distribution of continents and oceans has certain regularities. The oceans and continents are diametrically opposite, and only 3 percent of the area of the continents has land antipodal. Prey and Vening Meinesz have expressed this fact mathematically by showing that if the height or depth of the rock surface is expressed as a series of spherical harmonics, the first, third, fourth, and fifth harmonics are predominant. Vening Meinesz draws the inference that the present distribution of the continents is fixed by the presence in the mantle of convection currents with a certain number of cells. One would infer that the continental rafts would be drawn toward those parts of the world where the convection currents are falling. At first sight it appears strange that the dispersion of the continents occurred so late in the history of the earth. If the above argument is accepted, then the dispersion of the continents at the end of Mesozoic time must reflect a change in the convection patterns in the mantle at that time.

It is not easy to suggest a reason for a change in the convection pattern so late in geological time, but it may be the result of a gradually growing core, which, as its radius increased, would favor convection with a higher number of cells. It has been suggested that the present concentration of the land masses in one hemisphere is the result of a primevil convection current consisting of a single cell which swept the continental material to one area. Such a single cell convection pattern would, however, be set up only if the heavy iron core was then very small. The idea of a core growing through geological time, rather than one formed initially, has been postulated by H. C. Urey in recent years, and may now receive support from continental drift.

References and Notes

1. W. Gilbert, *De Magnete* (1600), book 4, chap. 3.
2. T. Nagata, *Rock Magnetism* (Maruzen, Tokyo, Japan, 1953).
3. ———, *Nature* 175, 35 (1955).
4. L. Néel, *Ann. géophys.* 7, 90 (1951).
5. N. D. Opdyke and S. K. Runcorn, *Plateau* 29, 1 (1956).
6. E. A. Johnson, Murphy, O. W. Torreson, *Terrestrial Magnetism and Atmospheric Elec.* 53, 349 (1948).
7. D. H. Griffiths and R. F. King, *Monthly Notices Roy. Astron. Soc. Geophys. Suppl.* 7, 103 (1957).
8. J. W. Graham, *J. Geophys. Research* 54, 131 (1949).
9. D. N. Miller and R. L. Folk, *Bull. Am. Assoc. Petrol. Geologists* 39, 338 (1955).
10. L. Néel, *Advances in Phys.* 4, 191 (1955).

11. C. A. Heiland, *Geophysical Exploration* (Prentice-Hall, New York, 1940).
12. J. W. Graham, *J. Geophys. Research* **61**, 735 (1956); *Advances in Phys.* **6**, 362 (1957).
13. S. K. Runcorn, *Proc. Geol. Assoc. Can.* **8**, 77 (1956).
14. P. M. du Bois, *Advances in Phys.* **6**, 177 (1957).
15. E. Irving and R. Green, *Geophys. J.* **1**, 64 (1958).
16. K. M. Creer, *Ann. géophys.* **14**, 373 (1958).
17. A. E. M. Nairn, *Nature* **178**, 935 (1956).
18. S. K. Runcorn, *Advances in Phys.* **6**, 169 (1957).
19. R. A. Fisher, *Proc. Roy. Soc.* (*London*) **217A**, 295 (1953).
20. N. D. Opdyke and S. K. Runcorn, *Bull. Geol. Soc. Am.*, in press.
21. P. Reiche, *J. Geol.* **46**, 905 (1938).
22. F. W. Shotton, *Geol. Mag.* **74**, 534 (1937); *Liverpool Manchester Geol. J.* **1**, 450 (1956).
23. For discussion of this subject, see W. H. Twenhofel, *A Treatise on Sedimentation* (McGraw-Hill, New York), p. 610.
24. G. C. Simpson, *Quart. J. Roy. Meteorol. Soc.* **83**, 459 (1957).
25. D. W. Collinson, K. M. Creer, E. Irving, S. K. Runcorn, *Phil. Trans. Roy. Soc.* (*London*) **250**, 73 (1957).
26. H. Jeffreys, *The Earth* (Cambridge Univ. Press, ed. 3, 1952), p. 392.
27. S. W. Carey, *Geol. Mag.* **92**, 196 (1955).
28. K. L. Hill and T. W. Dibblee, *Bull. Geol. Soc. Am.* **64**, 443 (1953).

News of Science

Scientists at Space Agency Seminar Compare Views on Composition and Origin of Van Allen Radiation Layer

On 26 and 27 March the Theoretical Division of the National Aeronautics and Space Administration held a conference on problems associated with the Van Allen radiation layer. The conference, one of a series of seminars on current theoretical problems in space exploration, was organized by NASA.

The discovery of an intense layer of radiation in the outer atmosphere first reported by Van Allen and his collaborators at the State University of Iowa, constitutes the most significant research achievement of the IGY satellite program. The discovery was reported by Van Allen on 1 May 1958, at a meeting of the National Academy of Sciences, and confirmed by Sputnik data released by the U.S.S.R. at the Moscow IGY conference in August 1958. The layer probably provides the explanation of the aurora borealis and other geophysical phenomena, and it will also influence the design of vehicles for manned space flight.

As yet, very little is known regarding the properties of the layer, and its origin and geophysical effects have been the subject of extensive speculation. At the beginning of the year it was clear that the time had arrived for an informal meeting on these problems. In accordance with its policy of stimulating and coordinating research in frontier areas of the space sciences, the National Aeronautics and Space Administration invited a group of physicists to Washington for a symposium on the theoretical problems associated with the existence of the Van Allen layer.

The conference included three formal papers, by T. Gold (Harvard), E. N. Parker (Chicago), and N. Christofilos (Lawrence Radiation Laboratory), which served as nuclei for the discussion. These were supplemented by contributions from S. F. Singer (Maryland), P. Kellogg (Minnesota), E. Ray (Iowa), C. McIlwain (Iowa), and many other participants. A series of vigorous debates generated high ambient temperatures, which testified to the success of the meeting.

Trapped in Orbits

A large amount of provisional material on the radiation layer has been published in the press and in the scientific literature. Some of the material is well enough established to stand the test of time, and this can be summarized very briefly. First, the layer is known to consist of charged particles because the intensity variations follow the configuration of the earth's magnetic field. The magnetic field acts on charged particles, but it does not act on neutral particles or on radiation. We know from a great deal of theoretical work, which goes back to papers published by the Norwegian physicist Stoermer 50 years ago, that these charged particles may be trapped in orbits in which they spiral about the lines of magnetic force in the manner of a helix, traveling back and forth between the north and south magnetic poles.

If the particle is produced on a line of magnetic force at an altitude which is well out of the atmosphere, where the air density is low, then it can live for a long time, going back and forth from one reflection point in the Northern Hemisphere to the conjugate point in the Southern Hemisphere. The estimates of the lifetime depend on altitude, and they range from seconds at a few hundred kilometers to years out at a thousand kilometers. Lifetime estimates have been made by Christofilos, Singer, and Kellogg; these were among the few theoretical results on which there was agreement at the conference.

Under the circumstance of extended lifetimes the particles can be fed into the layer at a very slow rate, but, because they stay there so long the population of particles will nonetheless build up to very substantial values. That is the key to the formation of the Van Allen layer.

Hard and Soft Components

The Pioneer III space rocket extended the radiation measurements out to a distance of 110,000 kilometers from the earth and showed that the layer actually contains two separate zones, with centers at 13,000 and 25,000 kilometers, respectively. The population of the inner zone may be divided into a soft component, with energies of the order of 100,000 volts, and a hard component, with energies of 6 million volts or more. The hard component is so named because it has sufficient energy to penetrate a 1-centimeter slab of aluminum in front of the shielded counters. It has always been assumed that the soft component consists of electrons, because electrons of the same energy and intensity had already been observed in rocket flights into the upper atmosphere. The penetrating particles of the hard component remained unidentified, but at the conference McIlwain and Ray reported for the Iowa group the result that these particles were definitely protons, with energies in the neighborhood of 100 million volts. The identification of the penetrating particles as protons rested on analysis of unexpected variations in the Explorer IV data, which indicated their specific ionization to be roughly 4 times minimum.

McIlwain and Ray also reported that the Pioneer data show the presence of a relatively penetrating component in the outer zone as well, with a range corresponding to electrons of 650,000 volts or more. The nature of the outer penetrating component is not known at the present time.

Solar Origin of Outer Zone

The probable origin of the layers was the subject of the liveliest debate at the conference. The origin of the belts may be either the beta decay of cosmic ray neutrons into electrons and protons or injection into the upper atmosphere by streams of particles coming from the sun. At the conference, Gold described a theory of solar origin in which gusts of plasma emitted from the sun established magnetic channels for the transit of energy-charged particles to the neighborhood of the earth. Parker has proposed, as an alternative theory of solar origin, that protons from the sun form a "solar wind," which may blow across the earth and inject particles in the Van Allen layer without prior establishment of a solar-terrestrial magnetic channel. Whatever the precise mechanism for transfer of particles to the layers, the solar origin of the outer zone appeared to be definitely established by preliminary Pioneer IV results presented at the conference. McIlwain and Ray reported that the radiation intensity in the outer zone was several times greater during the Pioneer IV flight than that observed in Pioneer III. They noted further that the Pioneer IV flight had followed directly on 5 days of continuous and unusually intense solar activity.

A judgment on the relative merits of the Gold and Parker theories will have to wait on further space-vehicle experiments, and in particular on the simultaneous measurement of magnetic field strengths and particle intensities during a period of varying solar activity.

Difficulties Remain

The origin of the inner zone is less clear, but the currently available evidence favors the beta-decay theory originally advanced by Singer, Christofilos, and Vernov (Moscow). Argus results reported at the conference by Christofilos indicate a remarkable stability of the inner-zone population, with no evidence of diffusion or mixing between the two zones. This result would appear to eliminate external streams as the origin of the inner zone.

Some difficulties remain in the beta-decay hypothesis. Estimates by Singer indicate that the decay of fast neutrons will yield perhaps 100 times more energetic protons than are actually observed. On the other hand, calculations by Kellogg on the yield of soft electrons from the beta decay of thermal neutrons indicate an intensity 100 times less than the observed intensity of the soft radiation. It is possible that these discrepancies may be accounted for by uncertainties in the values announced for atmospheric density, and by the approximations made in the course of a complex calculation.

The presence of a gap between the two zones poses a more serious problem. On the hypothesis of beta decay for the inner zone and a solar origin for the outer zone, we would expect the inner zone to rise smoothly into the outer, and it is difficult to explain the finding of a minimum in radiation intensity between the two. In this connection an interesting suggestion was made at the conference by Dessler (Lockheed, Palo Alto), who pointed out that there is an irregularity in the magnetic field of the earth over South Africa, an irregularity which may be described as a hole in the magnetic field. He pointed out, further, that the lines of force passing through this irregularity are located at the position of the gap between the zones. When particles are trapped on these lines of force in the magnetic field they descend to lower altitudes than would be the case in a perfectly dipole field. At the lower altitudes they pass through a denser atmosphere and are rapidly removed from the radiation layer.

ROBERT JASTROW
National Aeronautics and Space Administration

N. Christofilos describes the Argus results illustrating the stability of the inner Van Allen layer.

Nuclear Liability Problem Studied

The problem of nuclear liability is a growing one that is causing increasing concern. There is a risk that a catastrophic accident might occur in the operation of atomic power facilities and other nuclear installations. This could impose an overwhelming loss, both upon the public exposed to injury and also upon the enterprises operating or supplying the facilities. One of the groups that is studying this problem intensively is the International Atomic Energy Agency's Panel of Experts on Civil Liability and State Responsibility for Nuclear Hazards. This panel will hold a second series of meetings at IAEA headquarters in Vienna, beginning 11 May, as an outgrowth of a first series recently concluded.

IAEA Preliminary Findings

In the course of its first deliberations, the panel was provided with information on the safety evaluation of nuclear installations, the possibility of catastrophic accidents, the medical nature of injuries resulting from such accidents, the possible risks involved in the transportation and storage of nuclear fuels and radioactive materials, and emergency measures to be taken immediately after a nuclear incident. The panel agreed that, as a matter of first priority, it had to deal with the problem of civil liability for property damage and personal injuries from nuclear incidents. The experts also agreed that primary liability for such damage should not require proof of fault to be brought by the victim; that such

liability should be limited in time and in amount; that the state in which a nuclear installation causing damage was located should alone be competent to establish detailed rules concerning liability, apportion liability between private parties and the state, and designate a court to process claims by victims. The secretariat was asked to prepare a draft convention embodying these views, to be discussed at the May meetings.

The first series of meetings showed that the specialists were of the unanimous opinion that they should formulate minimum principles acceptable to all nations and that these principles should interfere as little as possible with existing liability concepts and legislative efforts undertaken on a national or regional basis.

The chairman of the panel is Paul Ruegger (Switzerland), who is a member of the Permanent Court of Arbitration and of the board of the Academy of International Law, both in the Hague, and an associate member of the Institute of International Law in Geneva. The United States representative on the panel, which has ten members from as many countries, is Edward Diamond, who has just resigned as associate general counsel of the Atomic Energy Commission.

Yugoslav Atomic Accident Studied

A new IAEA project is closely related to the work of the panel. Two specialists from the International Agency are visiting the Yugoslav Atomic Energy Center, the Boris Kidric Institute at Vinca, near Belgrade, to study the pattern of circumstances that led to an accident there last October. At that time, a group of young Yugoslav scientists were exposed to high doses of radiation during an experiment with the critical assembly (zero power reactor) at Vinca. All but one of the scientists, who were treated at the Curie hospital in Paris, have recovered and are back in their own country.

In view of the importance of obtaining all possible information that would be helpful in elaborating general safety criteria for atomic work, IAEA Director-General Sterling Cole asked for permission to send IAEA investigators for studies and discussions on the spot.

The staff members who are visiting Vinca are Dean Brown and David Newby, both from the agency's Reactor Division. Brown is an American theoretical physicist who has specialized in reactor physics. His activities in the United States, at the Savannah River Laboratory, were connected with reactor kinetics problems, and in the last 2 years he has worked on safeguard studies. Recently he has taken part in the evaluation of the power reactor at Halden, Norway. Newby has worked at the United Kingdom's Atomic Energy Research Establishment at Harwell, in reactor engineering, and has had experience in the field of safety of reactors and critical assemblies.

Atomic Forum–Harvard Law Study

Possible approaches to the international nuclear liability problem are the subject of a report published last month by the Atomic Industrial Forum, the national association of the United States atomic industry. Entitled *International Problems of Financial Protection against Nuclear Risk,* the report is based on a study conducted under the auspices of the Forum and the Harvard Law School by a Harvard research team headed by Robert B. Eichholz, former counsel for this country's foreign-aid program.

The new study points out that the risk of loss through nuclear accident should be allocated so as to give "reasonable protection to the exposed public, while not obliging atomic enterprises to risk an intolerable burden of liability." "Ideally," the report says, "a solution is called for which would embrace *all* nations participating in the development of nuclear power, and which would deal with all phases of the third party liability problem."

The report notes, however, that pending adoption of a global convention, a western European convention now in preparation under the auspices of the Organization for European Economic Cooperation could "serve on an interim basis as a partial groundwork for further international arrangements and national legislation." The report strongly recommends government indemnification for damages exceeding the limit for which operators and suppliers would be held liable under the draft O.E.E.C. convention and urges that this be provided for in advance rather than after the event. The Harvard study team suggests, further, that an opportunity exists to work out a satisfactory solution to the third-party liability problem under the joint nuclear power program of the United States and the six countries of the Euratom community, all of whom are members of the O.E.E.C.

The Havard study is the second major independent research effort on the liability problem that the Atomic Industrial Forum has underwritten. The first, a study conducted for the Forum by the Legislative Drafting Research Fund of Columbia University, was devoted to the domestic aspects of the problem.

Special grants from more than 30 member organizations of the Forum, and contributions from the American Insurance Association and the American Mutual Insurance Alliance, made the Harvard study possible. The report may be obtained, at $6 per copy, from the Atomic Industrial Forum, 3 E. 45 St., New York 22, N.Y.

Radiation Control Assessed for Public Health Service

A report on the control of radiation hazards that was prepared by the National Advisory Committee on Radiation for the Surgeon General of the U.S. Public Health Service was released on 26 March. Excerpts from the report follow.

During the past several years, a number of scientific bodies, including the National Academy of Sciences of the United States and the United Nations Scientific Committee on the Effects of Atomic Radiation, have reported extensively on the influence of ionizing radiation on biological systems. From these reports it is evident that serious health problems may be created by undue radiation exposure and that every practical means should be adopted to limit such exposure both to the individual and to the population.

The principal sources of ionizing radiation which have been created or developed by man include x-ray machines, nuclear reactors and their radioisotopic by-products, high-energy particle accelerators, a number of concentrated forms of naturally occurring radioactive materials, and the fall-out constituents of nuclear weapons. Among these sources, only nuclear reactors, their fuels, their radioisotopic by-products, and their radioactive wastes have been placed under substantial regulation from the standpoint of their influence on health and safety. This is notwithstanding the fact that extensive studies have revealed that most of the ionizing radiation received by the population today, other than received from natural sources, has been from the x-ray machines employed by the health professions. Concerted effort is now being applied by these professions to reduce, as far as is possible, the exposure of individuals undergoing x-ray diagnosis and treatment. Even so, the absence of a comprehensive program through which the health hazards of all sources of ionizing radiation may be brought under supervision appears to this committee to be an important weakness in this nation's efforts to control radiation safely.

In addition to the rapid, anticipated growth of the use of devices and products which produce ionizing radiation, there is another factor which urgently points to the nation's need for a comprehensive program governing the public health aspects of this radiation. This is the increasing respect given by scientists to radiation exposure as demonstrated by the steady downward revision, made

over the past thirty years, in the maximum permissible levels of ionizing radiation recommended by the National Committee on Radiation Protection and other authoritative groups.

Elements of Radiation Control

It may be worth while at this time to examine briefly the methods currently used in the United States in the formulation of standards of radiation protection. In regard to scientific data, considerable research in radiation biology, chemistry and physics is contributing to the store of scientific knowledge needed for standards development. This research is being supported by the Division of Biology and Medicine of the Atomic Energy Commission and the National Institutes of Health of the Public Health Service as well as many other governmental groups. Although the magnitude of this research is substantial, a review of current scientific data, which quantitatively relate radiation doses to biological effect, indicates that many gaps exist within these data and that such gaps pose great difficulty in the establishment of many radiation protection standards on a wholly satisfactory basis. Since standards of radiation protection are of fundamental importance, greater emphasis must be placed on radiation research in the future.

Much of the responsibility for the evaluation of radiation data, and the subsequent preparation of recommendations which may be used as guides by regulatory agencies in the development of their operational protection standards, has been borne in the United States by the National Committee on Radiation Protection, a private quasi-official group of internationally known American and Canadian scientists who are modestly supported in their work by the Department of Commerce.

From time to time, a number of individuals and groups have suggested that the N.C.R.P. should be made a component of some specific governmental agency. They believe that, under these circumstances, the committee would gain stature and its recommendations would benefit from the more official status given them. The National Advisory Committee on Radiation, however, believes that there is much merit in the independent position which the N.C.R.P. enjoys. In such a climate, the actions of the N.C.R.P. have been singularly forthright and decisive and it is felt that it would be unfortunate if these characteristics were changed.

State versus Federal Regulation

The Federal Government, under authority granted by the Atomic Energy Act of 1954, occupies a dominant position in the field of atomic energy. Through its control of atomic fuels, production facilities, utilization facilities, facility operators, by-product materials, classified data and patents, the Federal Government through its operating agency, the Atomic Energy Commission, exercises a profound influence over the development of atomic science in industry, medicine, and a large number of other areas within our social structure. In addition to its responsibility for the promotion and development of atomic energy, the Atomic Energy Commission has been given authority to regulate its operations and those of its contractors in such a manner that the safety of the population both individually and collectively may be maintained.

The propriety of the Atomic Energy Commission to perform a regulatory function in radiation safety was soon questioned by a number of groups which believed that such responsibility is a function of state and local agencies, rather than that of the Federal Government. This, incidentally, is not withstanding ample legal precedent where Federal regulatory power has preempted state responsibility in instances where national interest was at stake.

It is not difficult to suggest examples where national interest might not be well served if regulation of radiation protection in the field of atomic energy were delegated entirely to state and local agencies. First, circumstances frequently occur where radiation hazards do not respect state and local boundaries and serious danger may be expected to develop if wider control is not provided. Furthermore, the existence of a variety of local and state radiation protection codes, each with differing standards, might impede the development of atomic machinery and techniques to such an extent that national interest might be severely jeopardized. Finally, a high level of competence has been achieved by scientists associated directly and indirectly with the Atomic Energy Commission and their ability to provide the technical knowledge necessary for the execution of sound programs in radiation is substantial. Indeed, the performance of those so concerned constitutes a record of which the AEC may be justly proud. At the state and local levels, on the other hand, such competence is only now beginning to develop.

Arguments on Other Side

In spite of the foregoing, the arguments for state versus Federal regulation of radiation safety are not entirely on the Federal side. Although competence in radiation safety has lagged until recently in many state and local health departments and in other agencies concerned with safety problems, intensive efforts are now being made to correct this shortcoming. Also, history gives strong support to the concept that where regulatory controls are needed for the safety of a community, these controls may be best exercised where the authority responsible for control is not far removed from the group or groups being protected. This concept is likely to prove equally valid in the field of radiation protection, for many radioactive materials used in medicine and industry, even though initially regulated, eventually become a part of environmental contamination and of necessity must be evaluated at the point of human exposure as a part of a moral health assessment program. Finally, many state and local governments have demonstrated over long periods of time that they are quite capable of operating effective control programs in important areas of human activity; for example, the record of public health authorities is difficult to surpass in the field of sanitation.

After careful consideration of the problem of state vs. Federal control of radiation safety, the committee believes that many of the regulatory enforcement functions of a radiation control program may be discharged effectively by state and local governmental agencies. Also, the committee believes it unwise to continue the assignment of primary authority over the public health aspects of atomic energy in the same agency that has a prime interest in the promotional aspects of the field. By this, the committee in no way wishes to imply criticism of the Atomic Energy Commission. It merely wishes to express a principle which it believes to be fundamentally sound. Furthermore, the committee does not wish to imply that the A.E.C. should not continue to pursue intensive radiation safety programs for the control of hazards in its own installations and in those of its contractors and licensees. Indeed, on the contrary, the commission has an obligation to do so. In matters involving the protection of the public's health against ionizing radiation, the committee believes the ultimate authority should be placed in an independent agency and preferably in one with a special interest in public health, i.e., the U.S. Public Health Service.

Comments and Recommendations

The committee recommends that:

(1) Primary responsibility for the nation's protection from radiation hazards be established in a single agency of the Federal Government. The committee believes that this agency should logically be the U.S. Public Health Service, Department of Health, Education and Welfare, and urges immediate legislation to achieve this objective.

(2) The agency be granted authority for broad planning in the field of radiation control. Such planning should include the coordination of state and local regulatory programs with the safety operations of Federal and private groups in a manner which will provide a unified attack on problems associated with the control of radiation hazards.

(3) This agency be given authority to develop a comprehensive program of control for all sources of radiation. In this connection, the committee wishes to call attention to the following principles and additional recommendations. (A) Problems of radiation control frequently do not respect state or regional boundaries but extend across large areas of the nation. Therefore, the committee recommends that the agency be charged with the responsibility of promulgating uniform, national standards on radiation protection. In order to meet this responsibility, the agency should take full advantage of the guidance provided by the National Committee on Radiation Protection and by other organizations of similar character. Furthermore, the committee recommends that the agency be granted authority to undertake intensive research programs aimed directly at the provision of scientific data for the development of improved standards of radiation protection. (B) The committee recommends that as much regulatory responsibility as possible be vested within state and local governments in the field of radiation protection. However, in order that the agency may be assured of discharging its responsibilities to the nation as a whole, the committee recommends that the agency be granted supervening authority in those areas of enforcement where Federal regulation seems more appropriate. It also recommends that this authority apply under those circumstances where a state or local government finds itself unable to meet its obligations. Finally, in order that state and local governments may discharge their responsibilities with the greatest effectiveness, the committee recommends that the agency be granted authority to provide technical and financial assistance to such governments, as in other public health programs. (C) The committee recommends that the agency be granted authority to undertake a broad range of training programs which will assure that the nation, state and local needs for personnel trained in radiation protection will be satisfactorily met.

Program Budget

It is anticipated that the cost of a comprehensive program of radiation control which includes the elements set forth in the foregoing recommendations will reach a level of approximately $50,000,000 in a period of five years. The committee recommends, however, that the program be developed gradually, perhaps at a level of approximately $2,500,000 in the fiscal year 1959–60 and increasing in magnitude until full development is reached in 1965. There is no question that the present situation calls for bold and decisive action. With such action based upon sound principle, the committee believes that the Federal Government should proceed with all deliberate speed.

Radiation Committee Members

Russell H. Morgan, chairman, professor of radiology, Johns Hopkins Medical School.

Victor P. Bond, medical department, Brookhaven National Laboratory.

Richard H. Chamberlain, professor of radiology, University of Pennsylvania Hospital.

James F. Crow, professor of genetics, University of Wisconsin.

Herman E. Hilleboe, commissioner of health, State Department of Health, Albany, N.Y.

Hardin B. Jones, Donner Laboratory, University of California, Berkeley.

Edward B. Lewis, professor of biology, California Institute of Technology.

Berwyn F. Mattison, executive secretary, American Public Health Association, New York.

Lauriston S. Taylor, chief, Atomic Radiation Physics Division, National Bureau of Standards, Washington.

George W. Thorn, physician-in-charge, Peter Bent Brigham Hospital, Boston, Mass.

Abel Wolman, professor of sanitary engineering, Johns Hopkins University.

Arthur H. Wuehrmann, professor of dentistry, University of Alabama.

European Reactor Planned

An agreement by 12 Western European nations to construct and share an experimental high-temperature, gas-cooled reactor was signed in Paris on 23 March. Euratom, the common market in nuclear power established by the six nations of the wider European Common Market, signed as a single entity. Austria, Denmark, Great Britain, Norway, Sweden, and Switzerland signed independently.

The new project, known as "dragon," is the third joint undertaking to be organized by the European Nuclear Energy Agency, an offshoot of the Organization for European Economic Cooperation. The reactor is to be built in Britain at the Winfrith Heath Research Establishment. The other projects so far set up by ENEA are a European company for the chemical processing of irradiated fuels, with a plant at Mol in Belgium, and a boiling heavy water reactor at Halden in Norway.

The Berber Tribes

A 2-year study of the Berber tribes of Morocco, one of the oldest groups living in North Africa, has been announced by the American Museum of Natural History. The study will be carried out by anthropologist David M. Hart and will include a survey of the social, political, and cultural organization of the Berbers living in the Rif and High Atlas Mountains of Morocco. Hart plans to make tape recordings, films, and still pictures. He will return to this country in the spring of 1961.

The Berbers are thought to be direct descendants of the aboriginal peoples of North Africa, and evidence of their existence can be found in Egyptian tomb paintings as early as 2400 B.C. At present they inhabit the lands between the Sahara and the Mediterranean from Egypt to the Atlantic coast. Despite a history of conquests by other peoples, they have retained a homogeneous culture, and most still speak Berber, a Hamitic language. They are simple agriculturists, and most practice Islam.

NSF Publishes Scientific Information Bulletin

The National Science Foundation has started publishing a bimonthly news bulletin, *Science Information News*. The periodical will provide a medium for reporting new and improved methods of disseminating scientific information and news of projects, grants, surveys, and cooperative undertakings sponsored by the foundation and other federal agencies, and by other public and private organizations—domestic, foreign, and international.

The first issue, for February and March, deals principally with events surrounding establishment of the NSF Science Information Service and the expansion of its program activities in accordance with provisions of the National Defense Education Act. In future issues, news coverage will extend to all phases of significant scientific information work, including research and development on information problems, establishment and operation of new groups in the field, data and reference centers, translation and publication programs, exchange and dissemination of published and unpublished documentary material, meetings and conferences, and international programs and projects in the scientific information field.

On page 1 of the February–March issue, Alan T. Waterman, director of NSF, says that it is the foundation's hope that *Science Information News* will be truly representative of the field as a whole and will provide an effective mechanism for the exchange of information among

those working in it. Waterman ended his statement with an appeal for contributions and cooperation from interested individuals and organizations in this country and abroad. Communications should be addressed to the Editor, Science Information News, National Science Foundation, Washington 25, D.C.

Scientists in the News

KARL VON FRISCH, zoologist and former director of the zoological institutes of the universities of Rostock and Breslau, Poland; the University of Graz, Austria; and the University of Munich, Germany, has received the United Nations Kalinga Prize for the popularization of science. The prize was presented recently in the Paris headquarters of the United Nations Educational, Scientific and Cultural Organization. The £1000 award is offered annually by the Kalinga Foundation, an organization in India that was established by B. Patnaik, an Indian industrialist, to contribute to economic, social and cultural progress in the Indian state of Orissa. The winner is chosen by an international jury appointed by UNESCO.

Von Frisch is the author of more than 100 scientific studies dealing with his research on bees, their life, language, and sense of orientation. These studies have contributed greatly to present understanding of how insects and birds are able to navigate accurately. Among von Frisch's works are *You and Life, Memoirs of a Biologist,* and studies on the sense of hearing and the color sense of fish. *The Dancing Bees,* one of his best known books, was published in German and English; *Bees—Their Vision, Chemical Senses and Language* was published in the United States in 1950.

ALBERT P. CRARY, polar geophysicist, has been appointed chief scientist of the newly established United States Antarctic Research Program at the National Science Foundation. Crary has just returned from 2½ years in Antarctica, where he was station scientific leader of the Little America IGY Station and deputy chief scientist of the Antarctic Program of the U.S. National Committee for the International Geophysical Year. Thomas O. Jones is the director of the National Science Foundation antarctic program.

Scientific visitors to the United States from the United Kingdom are as follows:

L. ESSEN, senior principal scientific officer, Standards Division, National Physical Laboratory, Teddington, will be in this country from 10 to 19 May. He will present a paper at the 13th Annual Frequency Control Symposium, Fort Monmouth, N.J., and will also visit New York and Washington (16–19 May.)

J. A. LOVERN, senior principal scientific officer, Torry Research Station, Department of Scientific and Industrial Research Food Investigation, Aberdeen, Scotland, is attending the 50th anniversary meetings of the American Oil Chemists Society in New Orleans, 19–22 April. He will visit Empire, La.; Morehead City, N.C.; and Washington (11–18 April.) He will leave 29 April.

N. B. MYANT, assistant director, Medical Research Council's Experimental Radiopathology Research Unit, Hammersmith Hospital, London, arrived in March to work for 6 months with IRVING M. LONDON at the Albert Einstein College of Medicine, Yeshiva University, New York.

E. M. NICHOLSON, Director-General of the Nature Conservancy, London, will arrive in May.

HENRY K. BEECHER, H. I. Dorr professor of anesthesia at Harvard University Medical School, has recently been lecturing in Warsaw and Krakow, Poland, as a guest of the Polish Academy of Sciences.

HARRY G. LINDWALL, professor of organic chemistry at New York University, has been appointed research associate at the Olin Mathieson Chemical Corporation in New Haven, Conn.

ALBERT HEINS, professor of mathematics at Carnegie Institute of Technology, has been named professor of mathematics at the University of Michigan.

Other appointments at Michigan are as follows: HERMAN ZANSTRA, professor of astronomy and director of the Astronomical Institute of the University of Amsterdam, the Netherlands, will be visiting professor for 1959–60; and ROGER W. HOWELL, director of preventive psychiatry at the Lafayette Clinic in Detroit, and associate professor of psychiatry at Wayne State University, has been named associate professor of public health administration (mental health).

HERBERT R. J. GROSCH, physicist and former director of International Business Machine Corporation's Technical Computing Bureau in Washington, D.C., has been appointed manager of the space program for the IBM Military Products Division. He will be in charge of the Vanguard Center in Washington.

PAUL C. MANGELSDORF, professor of genetics and director of the Botanical Museum at Harvard University, has been named honorary professor by the National School of Agriculture at La Molina, Lima, Peru.

SCOTT ADAMS, former chief librarian and director of the Russian Scientific Translation Program at the National Institutes of Health, has been appointed program director for foreign science information in the National Science Foundation's Office of Science Information Service.

RICHARD P. CASTANIAS, formerly director of the Univac computer system installation at the Lockheed Missile Systems Division in San Francisco, has joined the Remington Rand Division of the Sperry Rand Corporation as West Coast representative of the vice president of Univac scientific systems.

A. G. MADDOCK, radiochemist at Cambridge University, Cambridge, England, is in Athens, Greece, lecturing for a training course organized by the Greek Atomic Energy Commission. Maddock is the first person to lecture under the specialists exchange program of the International Atomic Energy Agency.

STEVEN M. HORVATH, professor of physiology and director of the Institute of Gerontology at the University of Iowa, has been appointed physiologist at the research division of Lankenau Hospital, Philadelphia, Pa.

AKSEL C. WIIN-NIELSEN, formerly assistant professor of meteorology at the University of Stockholm, Sweden, has been named research meteorologist at the Joint Numerical Weather Prediction Unit, U.S. Air Force Air Weather Service, Suitland, Md.

Recent Deaths

JOHN H. COLLINS, Washington, D.C.; 46; veterinary medical director of the Food and Drug Administration; 30 Mar.

LELAND G. COX, Norwood, Mass.; 46; associate director of research for the United Fruit Company; 2 Apr.

J. JAMES EBERS, Allentown, Pa.; 37; assistant director of development for the Allentown Laboratory of Bell Telephone Laboratories; former assistant professor of electrical engineering at Ohio State University; holder of patents on transistors for switching operations; 31 Mar.

CHARLES C. HARRIS, New York; 72; president and director of the Lillian Babbitt Hyde Foundation, which contributes to research work on cancer and heart diseases and to educational activities; 30 Mar.

Sir ROBERT MUIR, Edinburg, Scotland; 94; emeritus professor of pathology at the University of Glasgow; formerly professor of pathology at St. Andrews University; 31 Mar.

Book Reviews

Zoogeography. Publication No. 51. Carl L. Hubbs, Ed. American Association for the Advancement of Science, Washington, D.C., 1958. x + 509 pp. Illus. $12; prepaid, to members, $10.50.

The title of this book, which will appear in book lists and some bibliographies, is simply *Zoogeography,* and the first paragraph of the preface says that the book is the product of symposia that "encompassed the field of zoogeography, with due attention to the underlying data of geomorphology, paleoclimatology, paleontology, and physiology." But the book is really concerned mainly with special aspects of animal distribution in western North America; it includes a little additional material but not enough to change the book's focus. Some simplification is (I hope) excusable in titling a book, but to publish this book as *Zoogeography* without immediately indicating its limits is seriously misleading and is likely to make unnecessary trouble and annoyance—especially for foreign buyers.

The book is also inadequately indexed. There are indices of authors and of scientific names and an "Index to subject coverage" (pages 474–475), but the last is not an index but a second, complicated table of contents. There is no subject index—no way to look up directly such subjects as (for example) "Bering bridge," "Continental drift," "Evolution," "Extinction," "Holarctic region," or "Tropics." All these criticisms concern the presentation of the book as a whole and not the individual papers in it.

The body of the book consists of 17 separate papers which were originally presented as two symposia. One symposium (14 papers) was on "The Origins and Affinities of the Land and Freshwater Fauna of Western North America" and was held under the prime auspices of the Pacific Section of the Society of Systematic Zoology, at Stanford University, in August 1957. The other (3 papers) was on "Geographic Distribution of Contemporary Organisms [chiefly in North America]" and was a feature of the annual meeting of the American Association for the Advancement of Science at Indianapolis, in December 1957.

The first paper in the book, by Philip B. King, "Evolution of modern surface features of western North America," is a concise summary of the geological history of the area in question, and it sets a very high standard both in content and in clarity of presentation. Several of the other papers are equally outstanding. The book is, therefore, a notable contribution to the zoogeography of western North America. I can do little more here than list the papers and indicate their contents very briefly. Paper number two, by H. D. MacGinitie, on "Climate since the late Cretaceous," traces climatic changes (chiefly in North America), with emphasis on fossil floras and on contraction and expansion of climatic and biotic zones around a fixed north pole. Number three, by George A. Bartholomew, "The role of physiology in the distribution of terrestrial vertebrates," stresses the complexity of the factors that limit species' distributions and warns that, although physiology helps to explain how vertebrates can live where they do, it rarely explains the exact limits of their distributions.

Number four is the first of several papers on the origins and affinities of particular groups of animals in western North America. It is by Donald E. Savage and is concerned with fossil land mammals. It treats well, and in some detail, the nature of the fossil record (especially in North America) and the apparent histories of orders, families, and minor groups that occur or have occurred in North America (but I think Savage makes too little allowance for the huge gaps in the fossil record in some parts of the world). Number five, by William H. Burt, treats Recent land mammals, analyzing the relationships that now exist between North American mammals and those of Asia and South America. The Bering land bridge is specially discussed, and it is clearly shown that ecological conditions, soil, and vegetation were more important than temperature in preventing some north temperate mammals from crossing the bridge (but temperature was presumably the primary factor that kept tropical animals from crossing). Numbers six and seven, by Alden H. Miller and Robert C. Stebbins, on birds and on reptiles and amphibians, respectively, are printed only as abstracts. Number eight, by Frank E. Peabody and Jay M. Savage, discusses the "Coast range corridor" that developed in California in the Pliocene and Pleistocene and that became a small-scale land bridge, which permitted north-south movements of amphibians and reptiles and explains their present distributions and the high incidence of sympatric species in southern California.

Number nine, by Robert Rush Miller, is a thorough and important treatment of the distribution and history of the freshwater fishes of western North America. Number ten, by Robert W. Pennak, briefly treats fresh-water invertebrates (except insects) of the western United States, pointing out among other things that their distribution is confusing and poorly known and that man is further confusing it by introductions.

Number 11 is by Herbert H. Ross, on the northern and montane insects of western North America. He gives detailed evidence, but drawn (as he says) from a small fraction of the insect fauna, of three main periods of dispersal of cold-adapted insects, in the mid-Cretaceous, Paleocene, and Pleistocene. Number 12 is by James A. G. Rehn, on the Dermaptera and Orthoptera. The complex distribution and history of these insects in North America are well reviewed, and summarized on page 298. Their greatest evolutionary center (in North America) has been Sonoran. Number 13, by E. Gorton Linsley, on the cerambycid beetles, is another good, detailed review of the distribution of an important group of insects in North America. Linsley finds that "the North American cerambycid fauna is a complex of diverse elements of which five are rather readily identified: the Holarctic, Neotropical, Alleghenian, Vancouveran, and Sonoran."

In number 14, William Hovanitz summarizes and diagrams the distribution of butterflies in the New World in relation to climatic zones and altitude, ending with discussions of controlling factors, changing distributions, and geographical origins of American butterflies. Number 15, by Paul S. Martin, is a review of Pleistocene ecology and biogeography of North America, with emphasis on displacement of climatic zones, arrival of prehistoric man, and late Pleistocene extinction of large vertebrates, which Martin suggests was due mainly to man. Number 16, by Kenneth C. Parkes, is concerned with the Palearctic element in the New World avifauna. A detailed analysis of distributions and apparent histories leads to two important but unanswered questions: "Why have some birds and not others moved (in one direction or the other) between Eurasia and North America?" and "Why has most of the movement been in one direction, from Eurasia to America?" Finally, number 17, by W. Frank Blair, describes distributional pat-

terns of vertebrates in the southern United States and shows how the patterns are explained by Pleistocene climatic and ecological changes, especially by southward shifting of climatic belts which split populations of warmth-adapted vertebrates and resulted in speciation in separate refuges in Florida and Mexico.

Under "General conclusions," Carl L. Hubbs notes the diversity of the papers that compose the book, the "emphasis on background considerations and on evolutionary and systematic correlatives" (but only within a very limited part of the world), the "kinetic approach" (which in fact began with Darwin), and the refined methods and high quality of many of the contributions (the praise is deserved). The editor notes also that biogeography is still a propitious field of inquiry, and that biogeographers show a [healthy] lack of preoccupation with transoceanic land bridges. However, real general conclusions—significant zoogeographic principles—are few in this book. Criteria for determining places or origin and directions of dispersal of animals are discussed, but no general conclusion is reached, except that tracing past histories is a complex and difficult matter. Several papers are concerned with the shifting of climatic zones, which (in North America) gradually moved southward (not northward, as Hubbs says inadvertently on page 473) during much of the Tertiary as the climate cooled, then pulsated violently during successive glaciations, complexly modifying plant and animal distributions. (No mention is made of Barghoorn's important paper, "Evidence of climatic change in the geologic record of plant life" [in *Climatic Change,* Harlow Shapley, Ed. (Harvard University Press, 1953)], which presents the evidence of southward shifting of climatic zones in North America from the middle Eocene to the Pleistocene.) Several contributors relate speciation to present distributions and past events in local situations, but the emphasis is on divergence of species rather than on evolution itself.

The broader aspects of zoogeography are missing in this book or, when touched, are not well handled. Donald E. Savage (pages 102–104) and Hubbs (page 473) dismiss the theory of Old World tropical origins of dominant vertebrates on the ground that much of the North Temperate Zone was tropical or subtropical in the earlier Tertiary. That the northern parts of the world were warmer in the Tertiary than they are now has been known by every competent zoogeographer since Darwin deduced it in 1858 (see Darwin's letter to Asa Gray in his *Autobiography* [Sir Francis Darwin, Ed. (Schuman, New York, 1950), p. 218]), although just how far north fully tropical conditions extended at particular times is still uncertain. But the shape and motions of the earth must always have caused some zonation of climate. The zonation has been enough to limit the sorts of mammals that have crossed the Bering land bridge at least since the late Eocene [see Simpson, *Evolution* (1947), vol. 1, pp. 218–220], and the distribution of dinosaurs suggests zonation in the Cretaceous. Moreover, even warm-temperature floras and faunas and fully tropical ones differ in more ways than just in being composed of different species. The tropical biotas are very much larger and more complexly integrated, and the species in them have different, sparser population structures. All this gives zoogeographers an opportunity not only to try to find where dominant animals have evolved in relation to climate but also, possibly, to discover fundamental things about the evolutionary process, about the situations and population-structures that influence it. That contributors to a symposium on local zoogeographic problems have missed this opportunity is not greatly to their discredit, but it brings us back to the point I started with. This book is a very good collection of papers on animal distribution (and some related subjects) chiefly in western North America, but it is not a zoogeography.

P. J. Darlington, Jr.
Museum of Comparative Zoology, Harvard University

American Voting Behavior. Eugene Burdick and Arthur J. Brodbeck, Eds. Free Press, Glencoe, Ill., 1959. iv + 475 pp. $7.50.

American Voting Behavior is a collection of some 22 essays mostly selected from four books each of which, in the opinion of Peter Rossi of the University of Chicago, represents a landmark in the research on voting behavior.

The four books he selects are *Quantitative Methods in Politics,* by Stuart Rice (1928); *The People's Choice,* by Paul F. Lazarsfeld, Bernard Berelson, and Hazel Gaudet (1944); *Voting,* by Bernard Berelson, Paul F. Lazarsfeld, and William N. McPhee (1948); and *The Voter Decides,* by Angus Campbell, Gerald Gurin, and Warren E. Miller (1954).

Most of the papers are written by sociologists and psychologists for sociologists and psychologists. The lay reader should arm himself with a glossary of terms currently popular among social scientists to be able to translate these contributions into understandable English. Agnes Meyer, one of the truly great students of social forces, has aptly described this contrived language as "desperanto."

The book would have much greater value if it were broader in scope. The contributors often reveal an amazing ignorance about election results and polling data and in some instances display an incredible naivete in their observations of voting behavior.

The contributors usually conform to the current ritual of social scientists by assiduously avoiding all conclusions except the inevitable one—namely, that "more research is needed before conclusions can be drawn."

A remarkable chapter was contributed by Leslie A. Fiedler of Montana State University. Fiedler, who is neither a sociologist nor a psychologist but a humanist, chides social scientists for "cloaking platitudes with a clinical vocabulary." He cites this example from *The Voter Decides*: "The results of both studies may be said to conform to the basic psychological principle that when strong and opposing forces act on an individual the resultant behavior will demonstrate the characteristics of conflict."

Some of the most interesting observations in the book on voting and voting behavior are offered by Fiedler. He wonders if it would not make more sense to characterize people by taste than by education, and he makes the very proper objection that in all of these studies there is not "sufficient prior speculation on the social meaning of the act of voting as such, opposed to the act of choosing one or another candidate."

We need to know more about voting behavior, and although this book confines itself to a small segment of this field, nevertheless it does demonstrate how the election process can be approached from the point of view of sociologists and psychologists. In this sense it is an important contribution to the scholarly literature in the field.

George Gallup
American Institute of Public Opinion

History and Philosophy of Science. An Introduction. L. W. H. Hull. Longmans, Green, New York, 1959. xi + 340 pp. Illus. $5.

This modest and well-written book deals, in a remarkably brief space, with the main lines of scientific thought from antiquity to the 20th century. As the title implies, theory rather than practice is emphasized. Hull's point of view, that "nearly all the most significant ideas behind modern science have their origin in [Greek science]," leads him to give a much more extended treatment of Greek science (altogether fuller than that of comparable general histories) than he gives of the science of later periods. His treatment of the 19th, and especially of the 20th, century is decidedly brief.

Hull gives an unusually coherent account of the succession and filiation of ideas, at the expense of particulars on experimental science. One of his greatest concerns is "the contrast between empirical and a priori methods," and in comparing the Alexandrian and Athenian periods, he gives credit to both, declaring, "The triumph of empiricism was necessary for science. But speculation was an essential first step . . ." (page 124). His comparison of these two periods is especially interesting. He points out with unusual clarity their philosophic differences and attributes them to the influence of the sophists and the neglect of Plato at Alexandria.

Particulars get even shorter shrift in his treatment of the last two centuries; important experimental scientists (Black, Liebig, and Michaelson) and even whole sciences (acoustics) get lost. The 18th century is not lost, as it appears to be, for it is considered in the chapter entitled "Other developments in the 16th and 17th centuries"! But, notwithstanding the brevity, the main lines of recent scientific thought are well discussed, and perhaps better elucidated because of the omissions, for significant particulars are brought in cogently to illustrate the argument.

Hull has begun his work with a disclaimer of any intention of dealing with technology. The scientist will therefore be surprised to find himself referred to on the first and last pages (but apparently nowhere in between!) as a "technician." This slip, if such it be, may be connected with the author's concern "that men of science shall have more in common with other men of thought. Perhaps then they will have less to do with men of power" (page 325). Hull believes history to be useful to the accomplishment of this laudable aim, but not just any history. "Let everyone know the history of his own subject" (page 325). A scientist could do much worse than to begin with Hull's book.

ROBERT P. MULTHAUF
Smithsonian Institution

Fundamentals of Advanced Missiles. Richard B. Dow. Wiley, New York; Chapman and Hall, London, 1958. xvi + 567 pp. Illus. $11.75.

In the preface to this book Dow describes his objective as ". . . a comprehensive treatment of the subject that will present fundamentals in broad perspective but without emphasis on any one type of system." In view of the enormous breadth of the field covered and despite the obvious difficulty of avoiding any reference to information covered by military security restrictions, he has substantially achieved his objective by compressing a fairly comprehensive treatment into one volume of only 555 pages. If there is to be any criticism of this work, it must be on the matter of thoroughness rather than comprehensiveness.

Following a brief historical introduction, the book begins in earnest with a mathematical treatment of flight kinematics, based primarily on geometric considerations. The second chapter, entitled "Application of fluid mechanics to aerodynamics and propulsion," continues the development of kinematics into the area of fluid flow and thermodynamics. It continues with an easily understandable treatment of shock waves and then goes on to discuss rocket and ram-jet engines, ending with an extremely abbreviated section on propellants and combustion.

The author seems almost to have gone out of his way to avoid introducing Newton's laws of motion until the last possible point in the book. The laws appear at the beginning of chapter 3, under the general heading "Dynamics." The remainder of this chapter develops the aerodynamics of bodies, wings, and composite configurations and discusses such subjects as maneuverability, aerodynamic heating, range computations, dynamic stability, and automatic flight control systems.

Although a skilled statistician or operations analyst would undoubtedly consider the chapter on "Application of probability and statistics" to be rather elementary, I thought it to be one of the more valuable sections of the book. The subject is one about which many engineers working in the field of missiles and space vehicles seem to be poorly informed. Although still in the nature of an introduction, this part of the book covers many important elements of subject matter, using well-selected illustrations from fields of guided-missile engineering such as lethality, accuracy, reliability, and signal-to-noise ratio.

Succeeding chapters on microwaves, infrared radiation, and radar will be interesting primarily to those who have had little previous opportunity to study such phenomena and their applications to guided missiles. Chapter 8, on guidance, tends to be more descriptive than the previous chapters and therefore appears to suffer even more from the restrictions imposed by security considerations.

The final chapter considers complete guided-missile systems and outlines the engineering of such systems. This chapter should be valuable for the same reason that chapter 4 is valuable—namely, that not enough engineers and managers in the guided-missile business understand what is involved in true system-design work.

Perhaps the most accurate over-all summarization of *Fundamentals of Advanced Missiles* is that the book is neither to be regarded as a complete and thorough work on most of the subject matter it purports to cover, nor is it brief enough to be considered as a handbook. For reasons of security, no doubt, the illustrations are generally taken from obsolete equipment, such as the SCR-584 radar and the V-2 rocket. The student who is beginning for the first time to study seriously any of the disciplines involved would be better advised to use standard textbooks in physics, chemistry, and mathematics, rather than this composite work; however, as a text for a review or refresher course offered to graduate engineers and others already working in the field, this single-volume introduction should be very suitable.

RICHARD W. PORTER
General Electric Company, New York

Traité de Paléontologie. L'origine des mammifères et les aspects fondamentaux de leur évolution. part 6, vol. 2, *Mammifères (évolution)*. Jean Piveteau, Ed. Masson, Paris, 1958. 962 pp. Illus. Cloth, F. 16,500; paper, F. 15,500.

The second volume of part 6 of the *Traité de Paléontologie* is the first of the two volumes on fossil mammals (other than primates) to appear. It includes consideration of the majority of the eutherian orders; essentially, only the Cetacea, Carnivora, and Artiodactyla among the eutherian orders and the noneutherian mammals are reserved for the as yet unpublished first volume.

A number of paleontologists collaborated in getting out this extremely useful reference manual: Lavocat, Dechaseaux, Vaufrey, Viret, Saban, Hoffstetter, Guth, and Schaub, as well as Piveteau, contributed significant portions. The ordinal divisions follow essentially the classical arrangement, although the sequence of treatment (not truly significant), is at variance with the convention represented, for example, in Simpson's classification. Classification within the orders follows, of course, the interpretations of the collaborators; thus, for example, Lavocat's arrangement of the condylarths closely follows that of Simpson, and Viret's handling of the perissodactyls follows Simpson's with but minor differences. On the other hand, Schaub's treatment of the rodents and Saban's divisions of the Insectivora exhibit significant modifications.

The taxonomic entities, including genera and higher categories within the orders, are treated in an encyclopedic manner, so far as the more important diagnostic or distinguishing features are concerned, and the work is profusely

illustrated, for the most part with the original illustrations used by the various investigators. Nevertheless, the magnitude of the undertaking, covering as it does 26 orders of mammals in a single volume, precludes the possibility of exhaustive treatment, and many genera are not considered. Moreover, although the manual has the descriptive title "L'origine des mammifères et les aspects fondamentaux de leur évolution," volume 2 is rather largely a syllabus of descriptive morphology; the amount of interpretation about development and affinities included in each of the chapters covering the orders varies somewhat, according to the writer. In view of the fact that the treatise is intended to serve as a manual, it is, of course, proper that the amount of interpretation and speculation included should be judiciously balanced against the amount of factual information, as it is here, so that the text can better stand the test of time.

An interesting feature that Piveteau has included is a discussion, with certain examples, of primitive man's portrayal of Pleistocene mammoths, horses, and rhinoceroses, as represented, for example, on wood, on ivory, and on cavern walls, principally in France. Particularly noteworthy, moreover, is the addition of a section by Dechaseaux on endocranial casts, to most of the chapters covering the various orders. Interesting new material is illustrated for certain groups, as is certain material which had been previously described by Edinger and others.

The coverage of the manual is worldwide, and it would appear that full advantage has been taken of the more important literature. The approach is rather different from that in Scott's *Land Mammals of the Western Hemisphere*, quite apart from the latter's obvious geographic restriction. This volume is more nearly comparable to Zittel's *Text-book of Palaeontology*, although it is much more comprehensive and, of course, up to date.

C. Lewis Gazin
U.S. National Museum,
Smithsonian Institution

National Advisory Committee on Research in the Geological Sciences, Canada, Eighth Annual Report, 1957–58. Geological Survey of Canada, Ottawa, Canada, 1958. 165 pp. $0.50.

The Advisory Committee has three purposes: "to stimulate and co-ordinate geological research carried on in Canada; to suggest research projects that should receive attention; and to aid in having these projects undertaken." The committee does not carry on research; its function is to stimulate research by the universities, by the federal and provincial departments of mines, and by other organizations equipped for the work.

The first part of this report gives a summary of the work of the committee for the period 1 Sept. 1957 to 31 Aug. 1958. The second part contains the report of the subcommittees covering the different fields of the geological sciences. Members of the committee and of each subcommittee are listed.

The annual survey of current geological research in Canada, compiled by I. F. Henderson, is included. This is a record of research in the universities, in the federal and provincial departments of mines, and in other, nonindustrial institutions. It does not include research by mining and oil companies. The research projects listed are grouped under main headings that cover the various branches of geological science.

The author index lists after each name the numbers of the projects, as listed in the survey bibliography, on which the individual is currently engaged.

Miscellaneous Publications

(Inquiries concerning these publications should be addressed, not to Science, *but to the publisher or agency sponsoring the publication.)*

Accreditation in Higher Education. Lloyd E. Blauch, Ed. Office of Education, Washington, 1959 (order from Supt. of Documents, GPO, Washington 25). 255 pp. Cloth, $2.50; paper, $1.50.

Action for Science under NDEA. Report of an association conference on the National Defense Education Act of 1958. National Science Teachers Assoc., Washington 6, 1959. 23 pp. Single copy, free.

Aging. A review of research and training grants supported by the National Institutes of Health. G. Halsey Hunt and Stanley R. Mohler. National Institutes of Health, Bethesda, Md., 1958 (order from Supt. of Documents, GPO, Washington 25). 50 pp. $0.35.

Amphibians and Reptiles of Southern Florida. Bulletin of the Florida State Museum, Biological Sciences, vol. 3, No. 5. William E. Duellman and Albert Schwartz. Univ. of Florida, Gainesville, 1958. 146 pp. $1.63.

Council of the Indian Institute of Sciences, Bangalore. Forty-Eighth Annual Report, 1956–57. The Institute, Bangalore City, India, 1957. 236 pp. This report provides a list of members of the council and of the staff, and a summary of the work in each department.

Ectoparasites of the Cottontail Rabbit in Lee County, Northern Illinois. Biological Notes No. 38. Lewis J. Stannard, Jr. and Lysle R. Pietsch. 18 pp. *A Guide to the Aging of Pheasant Embryos.* Biological Notes No. 39. Ronald F. Labisky and James F. Opsahl. 4 pp. Natural History Survey Division, Urbana, Illinois, 1958.

Educating Children in Grades Four, Five and Six. Bull. 1958, No. 3. Gertrude M. Lewis. 222 pp. $1. *English Language Arts in American High Schools.* Bull. 1958, No. 13. Arno Jewett. 128 pp. $0.50. Office of Education, Washington, D.C., 1958 (order from Supt. of Documents, GPO, Washington 25).

The Effect of Fellowships on Acceleration of Ph.D. Attainment. Tech. Rept. No. 14. Lindsey R. Harmon. Office of Scientific Personnel, National Acad. of Sciences–National Research Council, Washington 25, 1959. 13 pp.

Foote Canyon Pueblo, Eastern Arizona. Fieldiana: Anthropology, vol. 49, No. 2. John B. Rinaldo. 152 pp. $4. *Three New Birds from West Africa.* Fieldiana: Zoology, vol. 39, No. 25. Austin L. Rand and Melvin A. Traylor, Jr. 4 pp. $0.15. *Three New Birds from the Philippine Islands.* Fieldiana: Zoology, vol. 39, No. 26. Austin L. Rand and D. S. Rabor. 3 pp. $0.10. *New Species of Fresh-Water Catfishes from North Borneo.* Fieldiana: Zoology, vol. 39, No. 27. Robert F. Inger and Chin Phui Kong. 16 pp. $0.40. Chicago Natural History Museum, Chicago, Ill. 1959.

Highlights of Progress in Research on Cancer. pt. 1, 1957; pt. 2, January–March 1958. Items of interest on program developments and research studies conducted and supported January 1957 through March 1958 by the National Cancer Institute. PHS Publ. No. 623. National Cancer Institute, National Institutes of Health, Bethesda, Md., 1959 (order from Supt. of Documents, GPO, Washington 25). 54 pp. $0.25.

Human Tolerance to Prolonged Forward and Backward Acceleration. WADC Tech. Rept. 58–267. ASTIA Document No. AD 155749. Neville P. Clarke and Stuart Bondurant. 29 pp. *The Use of Color in Coding Displays.* WADC Tech. Rept. 55–471. ASTIA Document No. AD 204214. Donald W. Conover and Conrad L. Kraft. 16 pp. Wright Air Development Center, Wright-Patterson Air Force Base, Ohio, 1958 (order from the Armed Services Technical Information Agency, Arlington Hall Station, Arlington 12, Va.).

Migrations in New World Culture History. Raymond H. Thompson, Ed. Univ. of Arizona Press, Tucson, 1958. 68 pp. $1.

National Science Foundation, Eighth Annual Report. For the fiscal year ended 30 June 1958. National Science Foundation, Washington, D.C., 1959 (order from Supt. of Documents, GPO, Washington 25). 246 pp. $1.

A New Frog of the Genus Telmatobius *from Southern Ecuador.* Occasional Papers, No. 7. Harold E. Munsterman and Alan E. Leviton. Natural History Museum of Stanford Univ., Stanford, Calif., 1959. 5 pp.

Post-Graduate Training in the Public Health Aspects of Nuclear Energy. Fourth report, Expert Committee. WHO Tech. Rept. Ser. No. 154. 1958. 55 pp. $0.60. *Hospital Laboratory Services.* Second report, Expert Committee. WHO Tech. Rept. Ser. No. 160. 1959. 30 pp. $0.30. *Expert Committee on Addiction-Producing Drugs.* Ninth report, Expert Committee. WHO Tech. Rept. Ser. No. 161. 1959. 15 pp. $0.30. *Expert Committee on Malaria.* Seventh report, Expert Committee. WHO Tech. Rept. Ser. No. 162. 1959. 50 pp. $0.60. World Health Organization, Geneva, Switzerland.

Reports

Factors Contributing to Production of "Virus-Free" Tumors in Turkeys by Rous Sarcoma Virus

Abstract. Virus-neutralizing factors in tumor extracts and sera, age of the tumor, and the infecting dose of virus are important factors contributing to the infective titer of tumor tissue. Tumors produced with small amounts of virus may contain no demonstrable infective virus, and detectable inhibitory factors may or may not be present in tumor extracts or sera.

Bryan, Calnan, and Moloney (*1*) observed that the amount of infective virus obtained from chicken sarcomas was related to the infecting dose (ID) of virus. Indeed, when less than 1 ID_{50} of virus was employed, about 24 percent of such tumors yielded no virus at all. Similarly, when chicks were inoculated intracerebrally with less than 1 LD_{50} of virus, brains removed from the relatively few chicks that died contained no infective virus in four of five instances (*2*). Recently it has been found that sarcomas produced in turkeys with as much as 10,000 ED_{50} of chicken tumor virus yielded little or no extractable virus despite the fact that the dilution end point for tumor production by chicken tumor virus was identical in chicks and turkeys (*3*).

In the studies described here Beltsville white turkey poults 3 to 5 days of age were infected subcutaneously by injection of 0.2 ml amounts of suitably diluted virus into the wing web. Standard chicken tumor virus prepared by differential centrifugation (*4*) was used as seed virus in all experiments. Infectivity titrations were carried out in embryonated chicken eggs, by a modified pock-counting technique (*5*). Serial decimal dilutions of the inocula were injected onto the chorioallantoic membrane of groups of five eggs each, and after 10 days of incubation at 38°C the membranes were examined. Tissue homogenates for assay in eggs were prepared by grinding the tissue in a mortar with Alundum and adding sufficient diluent (*2*) to make a 10 percent suspension by weight, which was then clarified by centrifugation at 2000 rev/min for 20 minutes. When such homogenates were used for serial passage in turkeys, each suspension was subjected to additional centrifugation (*1, 6*) to insure the absence of intact tumor cells in the inoculum.

It has recently been shown (*7*) that extracts of turkey sarcomas produced with chicken tumor virus contain a potent inhibitor and that this inhibitor was stable to 56°C for 30 minutes. This inhibitor rapidly neutralized large quantities of Rous sarcoma virus but did not affect fowl pox, Newcastle, bronchitis, or influenza viruses. The data in Table 1 show that a potent inhibitor may also be present in the serum and that both the presence of inhibitor and the infecting dose of virus exert a marked effect on the infective titer of the tumor. Individual birds were selected to illustrate the limits of variation observed to date. In all experiments, extracts of turkey tumor tissue and serum were heated to 56°C for 30 minutes before use. Neutralization tests were performed in the usual manner by mixing serial decimal dilutions of tumor extract or serum with 500 pock-forming units of virus and allowing the mixture to incubate for 30 minutes at room temperature before inoculation into groups of embryonated eggs. The data show that: (i) when large amounts of virus were employed there was an inverse relationship between the infective titer of the tumor tissue and the inhibitory titer of heated tumor extract and serum and (ii) when small amounts of virus were employed, little or no infective virus was present in tumor homogenates. However, the sera from such birds contained little or no inhibitor, although inhibitory factors were occasionally detected in low titer in tumor extracts. It is of interest to recall the observation of Carr (*8*) that slowly growing tumors induced in brown Leghorn chickens yielded noninfective filtrates, provided that the tumors selected had been growing for more than 40 days. Subsequently Carr reported (*9*) that such tumors contained an inhibitor which was associated with serum antibody, and he suggested that the amount of antibody contained in the tumor was sufficient to inactivate all of the virus that could be obtained from the tumor cells.

Previous studies (*3*) have shown that serial passage of virus in turkeys was associated with a progressive loss in infectivity with each passage until the fourth passage, when extracts of such tumors were noninfective. Our data (Table 1) suggest that the inhibitory factors pres-

Table 1. Selected examples of variations in infective titers of tumors produced in turkeys by Rous sarcoma virus.

Bird No.	Infecting dose of virus (PFU)*	Time after infection (day)	Size of tumor†	Infective titer (log)	Neutralization titer	
					Tumor extract‡ (log)	Serum‡ (log)
130	10^8	12	++	−7.8	< −1.0	< −1.0
4911	10^9	22	++	−5.3	−2.0	−2.0
4941	10^8	22	++	−2.1	−4.0	−4.0
254	10^8	33	++	< −1.0	−3.0	−4.0
229	10^8	21	++	−4.6	−2.0	−2.0
320	10^8	38	+++	< −1.0	−3.0	−4.0
5996	1	25	+	< −1.0	< −1.0	−1.0
169	1	42	+	< −1.0	−2.0	< −1.0
5993	1	42	++	< −1.0	< −1.0	< −1.0

* PFU, pock-forming units. † Size: +, 6 to 8 mm in diameter, confined to wing web; ++, 9 to 15 mm in diameter, with frequent invasion of adjacent muscle; +++, 6 to 30 mm in diameter, with extensive invasion of surrounding tissues. ‡ Tumor extracts and sera heated at 56°C for 30 minutes.

Instructions for preparing reports. Begin the report with an abstract of from 45 to 55 words. The abstract should *not* repeat phrases employed in the title. It should work with the title to give the reader a summary of the results presented in the report proper. (Since this requirement has only recently gone into effect, not all reports that are now being published as yet observe it.)

Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to Contributors" [*Science* 125, 16 (1957)].

ent in tumor extracts and serum probably are responsible for this failure to propagate virus serially in turkeys. Inasmuch as such inhibitory factors resemble antibody and are not demonstrable until two or more weeks after infection, a second attempt was made to establish the virus in young turkeys. In this experiment, tumors were initiated in turkeys with 10^6 pock-forming units of virus and the tumors were collected 8 to 14 days after inoculation. Tumor extracts were prepared as described above and were used as inocula in subsequent passage in turkeys. Under these conditions, a series of six passages of virus was successfully carried out, and the infective titer of tumor tissue from the sixth passage was $10^{-8.8}$. The latent periods for tumor production in each passage were less than 5 days.

The studies described in this report (*10*) indicate that inhibitory factors in tumor extracts and sera, time of collection of tumor tissue, and the infecting dose of virus employed are important factors contributing to the infective titer of tumor tissue. It seems clear that the presence of potent inhibitory factors in sera and in extracts of tumors produced in turkeys with large amounts of virus is responsible for the failure to demonstrate infective virus in such tumors. In addition, tumors produced with small amounts of virus also frequently yielded no infective virus demonstrable by the methods employed. In this instance it is of interest that potent inhibitory factors were not associated with the absence of infectivity. However, far less potent inhibitory factors were occasionally detected in tumor extracts but not in the homologous serum and vice versa. Inasmuch as tumors produced with small-to-moderate amounts of virus may reasonably be assumed to resemble naturally occurring viral neoplasia, a detailed study of their nature appears to be warranted.

VINCENT GROUPÉ
FRANK J. RAUSCHER
Institute of Microbiology, Rutgers University, New Brunswick, New Jersey

References and Notes

1. W. R. Bryan, D. Calnan, J. B. Moloney, *J. Natl. Cancer Inst.* 16, 317 (1955).
2. V. Groupé and F. J. Rauscher, *ibid.* 18, 507 (1957).
3. ———, *Science* 125, 694 (1957).
4. W. R. Bryan, J. B. Moloney, D. Calnan, *J. Natl. Cancer Inst.* 15, 315 (1954).
5. V. Groupé, V. C. Dunkel, R. A. Manaker, *J. Bacteriol.* 74, 409 (1957).
6. V. Groupé, F. J. Rauscher, W. R. Bryan, *J. Natl. Cancer Inst.* 19, 37 (1957).
7. F. J. Rauscher and V. Groupé, *Federation Proc.* 17, 532 (1958).
8. J. C. Carr, *Brit. J. Exptl. Pathol.* 24, 133 (1943).
9. ———, *ibid.* 25, 56 (1944).
10. These studies were aided by a grant from the American Cancer Society.

15 December 1958

Two Antigenically Different γ-Globulins in Domestic Rabbits Revealed by Isoprecipitins

Abstract. Isoprecipitins used in an agar-gel immunochemical analysis of 500 normal sera obtained from several breeds of rabbits show that the individual rabbits contain one or the other or both of two γ-globulin antigenic specificities in their sera but never lack both of them.

Recent investigations have shown that components of serum from individual rabbits are antigenic in other rabbits (*1, 2*). The isoantibodies were produced by subcutaneous injections of serum plus paraffin oil type adjuvants; they were detected by the precipitin reaction and by passive cutaneous anaphylaxis in the guinea pig (*1–3*). Isoprecipitins were found which reacted with serum antigens having electrophoretic mobilities corresponding to those of α-, β-, and γ-globulins (*2*). When the sera of 90 normal rabbits were tested with six isoimmune sera in agar-gel tubes, the 90 rabbits could be differentiated into 13 groups on the basis of the presence or absence of precipitin bands (*2*). These results and those of Oudin indicate that several components of serum may induce isoantibodies.

This report presents evidence concerning the number and incidence of the antigenically different γ-globulins in normal rabbit sera. The isoimmune sera were obtained from rabbits immunized with serum from individual normal rabbits as previously described (*2*). The agar-gel techniques employed were those of double diffusion in plates (*4*), microimmunoelectrophoresis (*5*), and a modification of Björklund's inhibition technique (*6*). For the purpose of inhibiting reactions of antiserum with a specific antigen in double diffusion experiments,

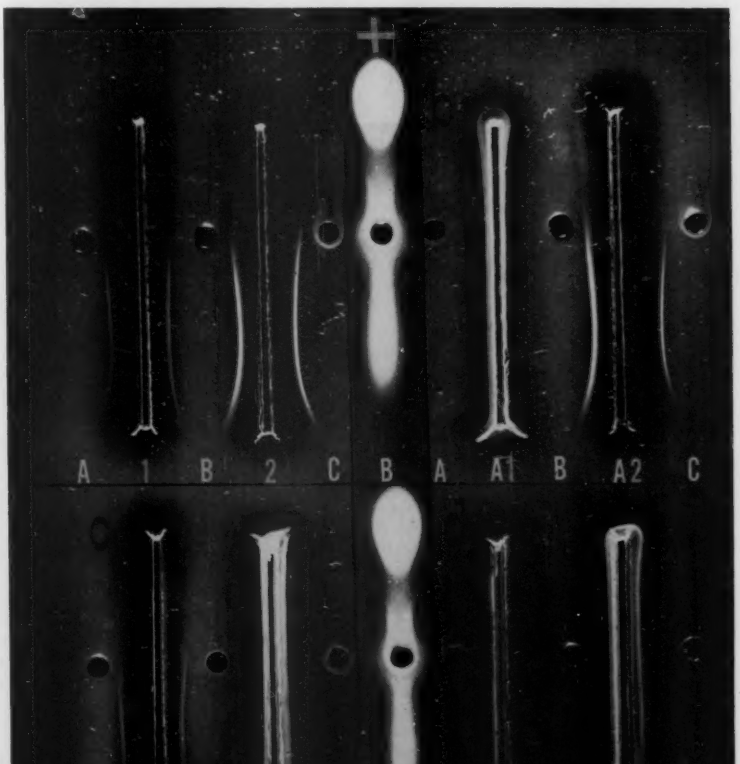


Fig. 1. Specific inhibition of the reactions of two isoimmune sera 1 and 2 in an immunoelectrophoretic plate by two different antigenic γ-globulins found in the sera of normal rabbits, A, B, and C.

the antigen solution was placed into the well or trough ½ to 1 hour prior to filling with the antiserum. This procedure permits the antigen to permeate the surrounding agar and provide an excess antigen zone of inhibition similar to that in Björklund's procedure, in which the antigen is incorporated into all of the agar (*6*). The procedure used is simpler and avoids heating the antigen, and less antigen needs to be employed.

Figure 1 is a photograph of the results of a typical microimmunoelectrophoretic experiment (*2, 5*). First, three undiluted normal rabbit sera, A, B, and C, were subjected to electrophoresis for 2½ hours under a field strength of approximately 3 v/cm in 1.5 percent (Noble) agar containing Veronal buffer at ionic strength 0.05 and *p*H 8.6. The troughs were then filled with 1:4 dilutions of sera in 0.15*N* NaCl as follows: no antigen in Fig. 1*a*, serum A in Fig. 1*b*, serum C in Fig. 1*c* and serum B in Fig. 1*d*. One hour later, when the troughs were practically empty, they were filled with isoimmune sera 1 and 2 (as indicated) which had been lyophylized and redissolved in distilled water to one-half the original volume. Twelve hours later the precipitin lines involving the γ-globulins were fully developed and photographed. The electrophoretic diagram of normal serum B obtained under the same conditions is superimposed on the results of double diffusion.

Figure 1*a* shows that isoimmune serum 1 has an antibody to a γ-globulin present in normal sera A and B; isoimmune serum 2, an antibody to a γ-globulin in normal sera B and C. Figure 1*b* shows that the previous filling of both troughs with normal serum A blocks the reactions of immune serum 1 but not that of immune serum 2. Also, the blocking reaction between normal serum A and immune serum 1 results in a precipitin line which encircles the trough. Similarly, Fig. 1*c* shows that the initial filling of both troughs with normal serum C blocks the reactions of immune serum 2 but not that of immune serum 1. Finally, Fig. 1*d* shows that all reactions are blocked by the previous filling of both troughs with normal serum B. Thus, the γ-globulin isoantigen in rabbit A has one type of specificity, hereafter designated as RGG-I, and the γ-globulin isoantigen in rabbit C has another type of specificity, designated RGG-II. Both types of γ-globulin specificities occur in rabbit B.

Figure 2 is a photograph of the results of a typical double-diffusion experiment in agar-gel plates (*4*), including the inhibition technique described above. The antigens and antibodies were used in the same concentrations as in Fig. 1. The notations A1, A2, C1, C2, B1, and B2 indicate that the wells were initially filled with the normal rabbit sera A, B, or C and 30 minutes later were filled with isoimmune sera 1 or 2.

As in Fig. 1, Fig. 2*a* shows the precipitin lines between isoimmune serum 1 and normal sera A and B and shows those between isoimmune serum 2 and normal sera B and C. The precipitin rings around the wells in Figs. 2*b*, 2*c*, and 2*d* show the selective blocking of these reactions by prefilling the antisera wells with sera A, C, and B, respectively. Moreover, as is shown in Fig. 2*a*, the reaction between immune serum 1 and immune serum 2 results in two precipitin lines. The line closest to the well containing immune serum 1 represents the reaction between the antibody from this well and the RGG-I present in immune serum 2. Similarly, the line closest to the well containing immune serum 2 represents the reaction between the antibody from this well and the RGG-II present in immune serum 1. This follows from the fact that these two lines coalesce with the corresponding lines resulting from the reactions of the immune sera with normal sera A, B, C, and D. The results of the inhibition procedure in Figs. 2*b*, 2*c*, and 2*d* also indicate that the coalescing lines represent identical antigen-antibody systems.

In order to pursue the question as to the number of such γ-globulin antigens in rabbits, the sera of 500 rabbits of several breeds (New Zealand white, Chinchilla, Dutch, Flemish giant, Race III, ACCR line, New Zealand red, and mixed breeds) and from three sources (NIH, Roscoe B. Jackson Memorial Laboratory, and local commercial breeders) were tested for the presence of RGG-I, and RGG-II; 24 rabbits were found with only RGG-I, 379 rabbits with only RGG-II, and 97 rabbits with both RGG-I and RGG-II in their sera. No rabbits were found to lack both γ-globulin specificities. All the possible "cross immunizations" among the above three known groups of rabbits have as yet (in 35 rabbits) failed to reveal a third γ-globulin specificity.

Quantitative studies are in progress to determine the proportion of the γ-globulin molecules in rabbit sera which have the specificity of RGG-I or of RGG-II

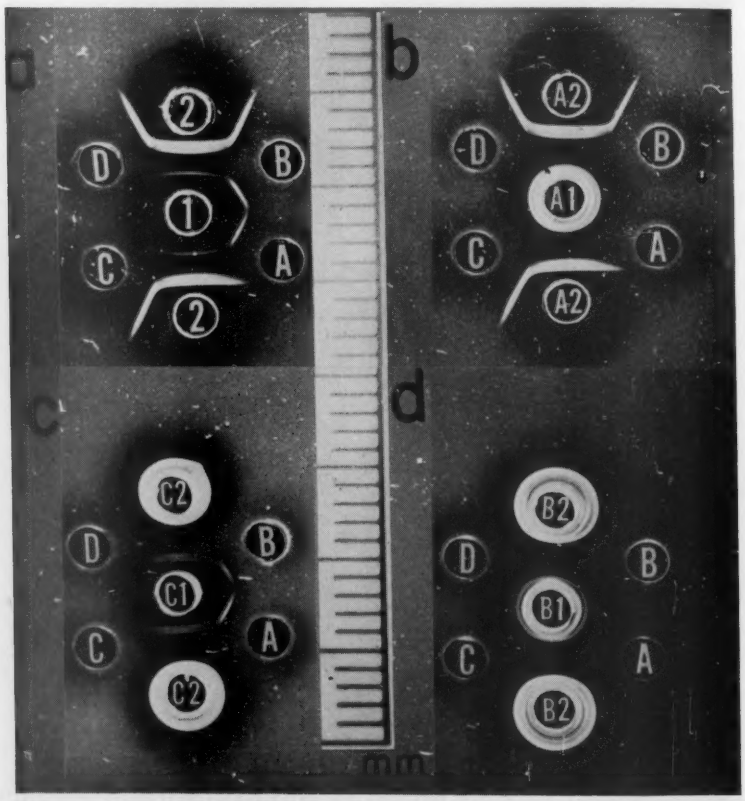


Fig. 2. Coalescence and specific inhibition of the precipitin lines resulting from the reactions between the sera of normal rabbits A, B, C, and D with the isoimmune sera 1 and 2 are used as criteria for identity or nonidentity of γ-globulin antigens in the various sera. Rabbit B was the donor to rabbit 1; rabbit D was the donor to rabbit 2.

with respect to the isoimmune sera and what proportion of the molecules may have neither specificity. Also, it will be interesting to determine whether in such rabbits as B, the specificities of RGG-I and RGG-II are on the same or different molecules (*7*).

SHELDON DRAY
GLENDOWLYN O. YOUNG
Laboratory of Immunology, National Institute of Allergy and Infectious Diseases, Bethesda, Maryland

References and Notes

1. J. Oudin, *Compt. rend.* **242**, 2606, 2489 (1956).
2. S. Dray and G. O. Young, *Federation Proc.* **17**, 510 (1958); *J. Immunol.* **81**, 142 (1958).
3. J. Freund, *Advances in Tuberc. Research* **7**, 130 (1956).
4. O. Ouchterlony, *Arkiv Kemi, Mineral. Geol.* **26**, 1 (1948).
5. P. Grabar and C. A. Williams, Jr., *Biochim. et Biophys. Acta* **17**, 67 (1955); J. J. Scheidegger, *Intern. Arch. Allergy Appl. Immunol.* **7**, 103 (1955).
6. B. Bjorklund, *Proc. Soc. Exptl. Biol. Med.* **79**, 319 (1952).
7. A paper describing some genetic considerations concerning these γ-globulins and their occurrence in various breeds of rabbits is in preparation.

22 October 1958

Development of a Chick Embryo Heart Cell for the Cultivation of Poliovirus

Abstract. An epithelial-like cell has been developed in line culture that apparently is stable. Although initially isolated cells were incapable of supporting the growth of poliovirus, the cells of the sixth and later passages allowed virus to propagate. The early, nonsusceptible cells were fibroblastic in appearance, in contrast to the epithelial type, poliovirus-susceptible, derived cell of later passages.

The use of cells in tissue culture for the propagation of poliovirus has been limited until recently to cells of primate origin. In 1957, Westwood, Macpherson, and Titmuss (*1*) developed a cell in line culture from embryo rabbit kidney. This cell was shown, by Sheffield and Churcher (*2*), to be capable of supporting the growth of the three types of poliovirus. Subsequently, Drew (*3*) and McCarthy and Tytell (*4*) reported the growth of poliovirus in other line cultures derived from rabbit kidney. Dunham and Ewing (*5*) demonstrated that cells derived from the chorioallantoic membrane of chick embryos were susceptible to the three types of poliovirus after five serial passages. Although it seems clear that cultures other than those of primate origin are capable of acquiring susceptibility to poliovirus when carried in passage, there may be an inclination by some to explain the susceptibility to poliovirus on the basis of contamination of the nonprimate cultures with cells of other susceptible lines. The work described in this report was conducted under conditions designed to minimize the possibility of such contamination.

This study concerns the development of a cell line from trypsinized chick embryo hearts which is capable of supporting the growth of poliovirus. Particular care was taken to insure against the possibility of contamination by other cell lines at all steps of the procedure. Trypsinized preparations were made in an area not used for other line cell work. Particular care was taken to limit the possibility of bacterial contamination of the various cell passages. The cultures were examined for contamination by pleuropneumonia-like organisms, with negative results.

The hearts were removed from 15- to 19-day-old chick embryos and placed in 100 ml of Hanks' balanced salt solution in a 250-ml flask. Approximately 45 hearts were used in each batch. A magnetic bar was placed in the flask and agitated in a magnetic field for 20 minutes. The fluid was poured off and replaced with an equal amount of 0.25-percent trypsin (Difco 1–250). Agitation was resumed for 2 to 3 hours, at which time the fluid was poured off and centrifuged at 1000 rev/min for 5 minutes; the pellet was then resuspended in medium 199 (*6*) containing 10 percent calf serum and adjusted to *p*H 6.8. Cells were planted in roller tubes at a concentration of 600,000 per tube, as counted in a hemocytometer.

Figure 1 shows fibroblastic-like cells isolated in the first passage of culture, and Fig. 2 shows epithelial-like cells which appeared in the fifth passage of culture. As transfers progressed, the line cells throughout the entire sheet were consistently of this type. Usually each passage was incubated for 7 to 10 days. The first four passages had as their typical and predominant cell an elongated fibroblast-like structure. In each passage, however, a few epithelial-like cells were present, and these increased in number with each transfer until at the fifth passage the culture consisted of approximately half fibroblastic and half epithelial cells. At the sixth passage most of the cells were epithelial, and at the seventh, a complete epithelial sheet was seen.

The three antigenic types of poliovirus were placed on chick heart cells of the first and sixth passages. No replication of virus was obtained on the first transfer, but on the sixth transfer all three virus types were propagated, yielding titers of 5.6, 5.5, and 5.2 for types I, II, and III, respectively, as determined by a metabolic inhibition test (*7*) with monkey kidney tissue. Virus produced by these cells was identified specifically

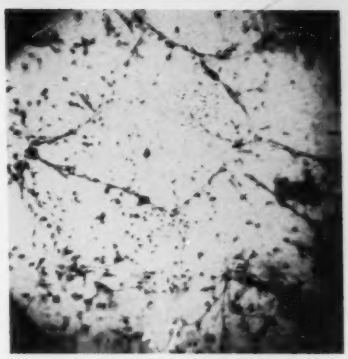


Fig. 1. Chick embryo heart cell, first passage (Giemsa stain). (About × 94)

by the complement-fixation procedure described by Mayer *et al.* (*8*).

It has been shown that several line cell cultures from various mammalian sources have a common antigen, as determined by complement-fixation techniques (*9*, *10*). A. A. Tytell of the Merck Sharp and Dohme research laboratories (*11*) has examined the chick embryo heart cells and has found that those permitting poliovirus replication contained the common antigen, whereas the early passage strains resistant to poliovirus did not have the common antigen. Several explanations have been offered regarding this observation (*10*), and projects under consideration for the use of cells containing the common antigen for the production of virus vaccines must be deferred until the significance of the common antigen is understood.

It is of interest that a tissue culture series, originating with heart tissue, in which the cell type appears almost entirely fibroblastic has yielded an epithelial culture. The cell type has been obtained on two occasions from four attempts. One line now has been main-

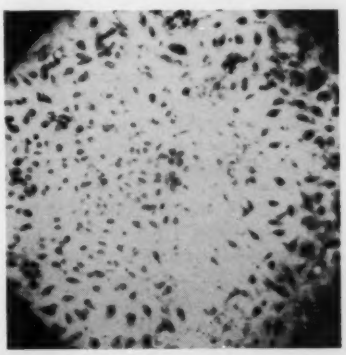


Fig. 2. Chick embryo heart cell, fifth passage (Giemsa stain). (About × 94)

tained for 15 passages and is stable for this period. There is little doubt, therefore, that in the present study the derived line cell originates from the primary tissue used (*12*).

J. E. PRIER
R. SULLIVAN
Biological Development Department,
Merck Sharp and Dohme,
West Point, Pennsylvania

References and Notes

1. J. C. N. Westwood, I. A. Macpherson, D. H. J. Titmuss, *Brit. J. Exptl. Pathol.* 38, 138 (1957).
2. F. W. Sheffield and G. M. Churcher, *ibid.* 38, 155 (1957).
3. R. M. Drew, *Science* 126, 747 (1957).
4. F. J. McCarthy and A. A. Tytell, *Federation Proc.* 17, 525 (1958).
5. W. B. Dunham and F. M. Ewing, *Proc. Soc. Exptl. Biol. Med.* 95, 637 (1957).
6. J. F. Morgan, H. S. Morton, R. C. Parker, *ibid.* 73, 1 (1950).
7. J. E. Salk, J. S. Youngner, E. N. Ward, *Am. J. Hyg.* 60, 214 (1954).
8. M. M. Mayer, H. J. Rapp, B. Roizman, S. W. Klein, K. M. Cowan, D. Lukens, C. E. Schwerdt, F. L. Schaffer, J. Charney, *J. Immunol.* 78, 435 (1957).
9. J. L. Melnick and K. Habel, *Federation Proc.* 17, 526 (1958).
10. L. L. Coriell, M. G. Tall, H. Gaskill, *Science* 128, 198 (1958).
11. A. A. Tytell, personal communications.
12. The assistance of Mary E. Wick is gratefully acknowledged.

25 November 1958

Failure of Survival of Slowly Growing Members of a Population

Abstract. Water in which tadpoles or fish have grown inhibits growth of others of their own kind. Larger animals may completely suppress the growth of smaller ones and may eventually kill them by this water-borne inhibition. Under natural conditions of overproduction only the more rapidly growing would be expected to survive.

Work with various fish and tadpoles has indicated that each species as it grows releases growth-inhibiting products which act in feedback fashion. The inhibitory products, in the case of tadpoles, may be removed from the culture water by heating, freezing and thawing, centrifugation, filtration, or sonication (*1*).

The effect of larger animals on smaller ones is such that, for example, one *Rana pipiens* tadpole growing rapidly in 6 lit. of water with 3 lit. replaced daily will completely inhibit the growth of smaller *R. pipens* tadpoles.

Water from growing tadpoles inhibits the growth of smaller tadpoles. If food is withheld from large tadpoles their culture water is not inhibitory to smaller tadpoles. It seems that products of growth collect in the aqueous medium and tend to limit growth. The effect is more marked when the products come from larger tadpoles and are used on smaller ones.

Similar relationships have been observed with young, growing fish. A pair of White Cloud mountain fish, *Tanichthys albonubes,* produce many more fertile eggs in a 15-lit. aquarium than can grow to 1-cm size. No matter how many hatch, even as many as 200, never more than 20 reach 1-cm size. Shortly after feeding begins, differences in size appear. The larger fish continue to grow; the smaller ones stop eating and die in spite of an abundance of food.

There is nothing inherently wrong with the smaller fish. They can grow if they are removed to other aquaria, and all may live if the groups are smaller than 20. They can also grow in the original aquarium if their larger siblings are removed.

A more striking demonstration that products, rather than a deficiency of food, limit survival was obtained with another fish, *Barbus tetrazona.* This fish has larger eggs and can use as its first food small soil nematodes and granules of yolk from hard-boiled eggs. A slight excess of food was present at all times. From a spawning of over 200 never did more than 15 survive to 1-cm size in a 15-lit. aquarium. The survivors were always the most rapid early growers. The number of survivors to 1-cm size was increased to 174 by replacing one-half of the water two, three, and toward the end of the experiment, four times a day.

In view of the fact that the production of fish was increased more than tenfold by frequent water changes, it might seem strange that one large tadpole could completely inhibit smaller ones when water was changed frequently. This is not due to a difference between tadpoles and fish. The growth of a group of tadpoles all of the same size is also greatly increased by water changes. The important thing is that when larger and smaller animals are together, the inhibitory effect of the larger is so great that it is effective even when half of the water is replaced daily. This is true for both tadpoles and fish.

Under natural conditions of overproduction more organisms begin development than can survive. From the above results it is suspected that any genome which led to a decrease in growth rate would be a death warrant. A new genome that favored growth might spread rapidly, for its bearers would inhibit their more slowly growing relatives without being inhibited by them. This may be a relationship favoring rather rapid evolutionary advances in aquatic organisms (*2*).

S. MERYL ROSE
Department of Zoology,
University of Illinois, Urbana

References and Notes

1. C. M. Richards, *Physiol. Zool.* 31, 138 (1958).
2. This work was supported in part by a National Science Foundation grant (NSF G-5542).

17 November 1958

Neopilina (Vema) ewingi, a Second Living Species of the Paleozoic Class Monoplacophora

Abstract. In December 1958 the Lamont Geological Observatory research vessel "Vema" dredged four specimens of Monoplacophora from the Peru-Chile Trench off northern Peru. This is the second discovery of living representatives of this class of Mollusca which was thought, until 1957, to have become extinct in the Devonian. The specimens are considered to represent a new subgenus and species: *Neopilina* (*Vema*) *ewingi,* and the discovery suggests that more relict types may exist alive in the deep sea off Central and South America.

On 6 and 7 December 1958, members of the scientific staff aboard the research vessel "Vema" dredged four fresh monoplacophoran mollusks from two localities in the north end of the Peru-Chile Trench off Peru (stations 150 and 151). These specimens are considered to represent a new subgenus and species of the Cambrian-Devonian class Monoplacophora. As such they differ in several significant respects from *Neopilina* (*Neopilina*) *galatheae* Lemche, 1957 (*1, 2*), the other living species of this class trawled by the Danish ship "Galathea" off Costa Rica in 1952.

The localities at which the specimens were dredged are: station 150, lat. 7°35′S, long. 81°24′W, in 3183 to 3192 fathoms (corrected); and station 151, lat. 7°30′S, long. 81°25′W, in 3195 to 3201 fathoms (corrected). These localities are over 1300 miles south-southeast of, and 1200 fathoms deeper than, the Galathea station 716 (lat. 9°23′N., long. 89°32′W.) in 1963 fathoms (corrected) and are separated from that locality by the Cocos Rise.

Although analyses of ecological and geological data are still incomplete, in view of the wide interest in this class and its importance to paleoecology, molluscan evolution, and interphylum relationships (*3*), it seems advisable to publish this preliminary report (*4, 5*).

The specimens were collected by us, J. Lamar Worzel, chief scientist, Thomas G. Dow, of Lamont Geological Observatory, and Juan J. Rivero, a visiting

Table 1. Measurements of the types.

Length (mm)	Width (mm)	Height (mm)	Apex to anterior margin (mm)
	Holotype, station 150		
15.5	14.0	5.0	3.0
	Paratype, station 151		
12.5	10.7	4.5	2.0
9.2	7.6	2.9	1.5
	Paratype, station 150		
4.9	3.7	1.5	0.8

scientist from the University of Puerto Rico (*6*).

Genus *Neopilina* Lemche, 1957 (*1*). Type species: *Neopilina galatheae* Lemche, 1957, by monotypy. Subgenus *Vema*, new subgenus. Type species: *Neopilina* (*Vema*) *ewingi*, new species.

The subgenus has the characters of its type species. The shell and animal are similar, in a general way, to those of *Neopilina* (*Neopilina*) *galatheae*, but there are prominent differences, as follows. Six pairs of gills are present in subgenus *Vema*, while only five pairs occur in subgenus *Neopilina*. The postoral tentacles are approximately half again as numerous in *Vema* as illustrated for *Neopilina*. The periostracum is all but invisible in *Vema* but is prominent in *Neopilina*, in the latter being blackish near the apex and changing to light brown near the margin. In addition, the shell in *Neopilina* is much thicker than in *Vema*, the radial lines are more irregular and fewer, and the whole sculpture is much coarser.

The taxonomic value of characters in the Monoplacophora is quite uncertain at the present time because so few specimens are known. Because the animal has not yet been sectioned and studied in detail, it is considered only as representing a new subgenus. The subgenus is named for the research vessel.

Neopilina (*Vema*) *ewingi*, new species (Fig. 1). Shell patelliform, ovate, thin, semitransparent, and pale yellowish white. Apex prominent, anterocentral, pointed, and curved ventrally. Aperture ovate, somewhat longer than wide, and with smooth margins. Shell sculpture consists of many fine, concentric, raised threads which are best developed near the apex, and a large number of poorly defined, low, radial riblets. In addition there are numerous (about 300 in the holotype) fine, concentric lines between the concentric threads, and a great many (about 700 in the holotype) fine, radial lines which together with the concentric lines delimit a vast number of rectangular prismatic units. In the holotype, the shell (unsectioned) appears to be constructed principally of these units with the addition of a very thin, lustrous layer on the inner surface and a pale yellowish, diaphanous, transparent periostracum, clearly visible only where it projects beyond small irregularities in the apertural margin.

The animal is similar in a general way to *Neopilina galatheae*—that is, it has a large, flat, subcircular foot surrounded by the mantle which bears the gills; an anterior mouth and associated appendages; and a posterior anus. Gills are arranged in two rows of six, one row on each side of the foot, and each bearing about five (specimen illustrated) to seven lamellae (holotype). The two palp-like

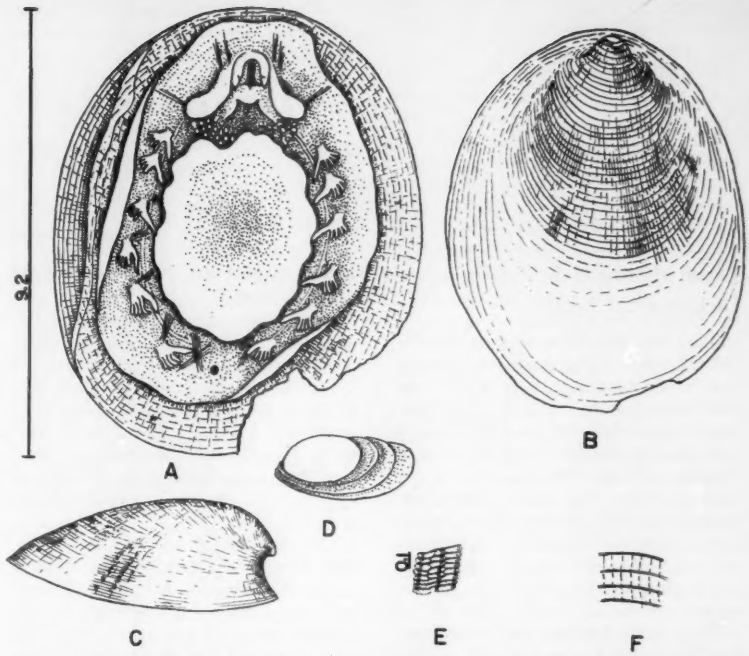


Fig. 1. *Neopilina* (*Vema*) *ewingi*, new species. *A*, Ventral view of paratype; *B*, dorsal view of another paratype; *C*, lateral view of paratype, (specimen *A*); *D*, apical portion of shell of paratype; *E*, *F*, striations on shell of paratype. Scale in millimeters. [R. J. Menzies]

appendages adjacent and lateral to the mouth are more elongate and lanceolate than in *N. galatheae*, and the postoral tentacles are much more numerous.

The holotype is from "Vema" cruise 15, station 150, about 140 mi west of Chicama, Peru, in 3183 to 3192 fathoms and is No. 220849 in the Museum of Comparative Zoology, Harvard University. A paratype from the same locality is on loan at the U.S. National Museum. The other paratypes are at Lamont Geological Observatory. Measurements of the types are given in Table 1.

All the specimens were dead upon arrival on deck. At that time the whole ventral surface, especially the foot and gills, was obscured by a thick layer of mucus. This indicates that the animal indeed does secrete a mucous film to aid in locomotion, as suggested to us by K. G. Wingstrand from his study of the anatomy of *N. galatheae*. It was also noted that only minor contraction occurred upon fixation and preservation and that the appendages were not significantly different in shape from their appearance in the figures drawn from preserved material. Before fixation the membranous portion of the foot was bluish with a diffuse, pinkish central area; the cephalic region was pale orange tan; and the muscular border of the foot, the gills, and the mantle were all pale yellowish tan.

The species is named in honor of Maurice Ewing, director of Lamont Geological Observatory, who has done more than any other American scientist to encourage modern deep-sea biological research and whose indefatigable efforts resulted in the "Vema" cruise 15 and the discovery of this species.

ARTHUR H. CLARKE, JR.
ROBERT J. MENZIES
Lamont Geological Observatory, Columbia University, Palisades, New York

References and Notes

1. H. Lemche, *Nature* 179, 413 (1957).
2. ——— and K. G. Wingstrand, *XVth Intern. Congr. Zool.* 14th Congr. (1958), sect. 4, paper 24.
3. H. Lemche, *ibid.* paper 22; ———, *ibid.* paper 23; C. M. Yonge, *Nature* 179, 672 (1957); J. B. Knight and E. L. Yochelson, *Proc. Malacol. Soc. (London)* 33, 37 (1958); R. L. Batten, *Natural History* 67, No. 3, 48 (1957).
4. This report is contribution No. 341, Lamont Geological Observatory, and Marine Biology contribution No. 37.
5. A report on the ecological and geological observations and on additional details of anatomy is in preparation.
6. W. J. Clench, D. R. Crofts, Maurice Ewing, Henning Lemche, R. D. Turner, K. G. Wingstrand, and J. Lamar Worzel have participated in helpful discussions or correspondence with us. The laboratory research was supported by a gift (RK-57076) from the Rockefeller Foundation for research in marine biology. The collections made aboard ship were made possible by contract with the Office of Naval Research and the Bureau of Ships, U.S. Navy, and by a grant from the National Science Foundation. We sincerely appreciate this aid.

4 February 1959

Meetings

Logan Meeting of the Pacific Division of the AAAS

The 39th annual meeting of the Pacific Division of the American Association for the Advancement of Science was held on the campus of Utah State University, Logan, 16–20 June 1958. Twenty scientific organizations participated in a program on which 325 scientific papers were presented. The total registered attendance was 922, not including the local townspeople, who contributed in substantial numbers to the large and appreciative audiences at the public evening lectures.

This was the first time the Pacific Division had met at Logan, and it is an understatement to say that persons attending the meeting were unprepared for what they found. Utah State University (formerly Utah State Agricultural College) occupies an elevation, which is itself of interest as the shore line of an ancient lake, overlooking Cache Valley, which was the lake bed. This beautiful, secluded valley, entirely surrounded by imposing mountains, is one of the most fertile farming areas in America, producing an annual yield of some $5 million worth of agricultural products.

In contrast to the arrangements for meetings held in metropolitan areas, delegates were fed and housed on the university campus, and all activities and entertainment centered there; this made for a compact, well-integrated meeting. The pleasant surroundings, the excellent facilities provided by the university, the atmosphere of friendly hospitality, and the efficient planning of the local committee combined to make this a memorable occasion.

Registration headquarters were in the Student Union building, an attractive structure of modern design which provided a spacious area for exhibits of scientific books and instruments, pleasant quarters for informal meeting and discussion, and excellent dining facilities. The luncheons and dinners of the various societies were conveniently accommodated here.

Social events also included a reception by President Daryl Chase of Utah State University, and Mrs. Chase, in the garden of the president's house; a breakfast for ladies in beautiful Logan Canyon; and an outdoor chicken barbecue for the entire gathering.

There were two general evening sessions—the divisional symposium on Monday, 16 June, and on Tuesday evening the presidential address of Ian Campbell, president of the Pacific Division, who spoke on the topic, "The industrial minerals, research, and mineral policies." Campbell is chairman of the division of geological sciences at California Institute of Technology.

The divisional symposium, on "Cenozoic History of the Western United States—Geomorphic, Climatic, Geological," was sponsored jointly by the Pacific Division and the Utah Academy of Sciences, Arts, and Letters. Daniel I. Axelrod of the University of California at Los Angeles discussed "Changing Tertiary environments in the Far West." Charles B. Hunt of the U.S. Geological Survey spoke on "Late Pleistocene and Recent Geology as a Factor in Plant Ecology and Soils." J. Stewart Williams, dean of the Graduate School, Utah State University, presided.

At the meeting of the divisional council on Wednesday afternoon, 18 June, Henry P. Hansen, dean of the Graduate School at Oregon State College, Corvallis, was elected president-elect of the Pacific Division. The president of the division for the coming year is Henry Eyring, dean of the Graduate School at the University of Utah, Salt Lake City. Ian Campbell, as retiring president, becomes chairman of the executive committee.

Elected to membership on the executive committee were George E. Lindsay, director of the San Diego Museum of Natural History, and R. M. Hagen, professor of irrigation at the University of California at Davis. Elected to the council were Frances N. Clark of San Pedro, Calif., and Franklin I. Badgley, University of Washington.

Raymond L. Taylor, associate administrative secretary of the AAAS, addressed the council briefly as a representative of the national organization.

Societies meeting in conjunction with the Pacific Division were the American Chemical Society (Salt Lake Section); American Meteorological Society; American Nature Study Society (Western Section); American Phytopathological Society (Pacific Division); American Society of Agronomy (Western Branch); American Society for Horticultural Science (Western Region); American Society of Ichthyologists and Herpetologists (Western Division); American Society of Limnology and Oceanography (Pacific Section); American Society of Plant Physiologists (Western Section); Botanical Society of America (Pacific Section); Ecological Society of America (Western Section); Herpetologists League; National Association of Biology Teachers (Western Section); Nature Conservancy; Society of American Bacteriologists (Intermountain Branch); Society of Systematic Zoology (Pacific Section); Utah Academy of Sciences, Arts, and Letters; Western Society of Crop Science; Western Wheat Conference; and Western Society of Soil Science.

The 922 registered members and guests were drawn from a wide geographical area, as shown in Table 1. Though this

Table 1. Geographic distribution of registrants at the Logan, Utah, meeting of the Pacific Division of the AAAS. Italics indicate the seven states, the Territory of Hawaii, and the Canadian province of British Columbia that comprise the area of the Pacific Division. The combined registration from these areas was 762, or 83 percent of the total.

Continental United States		Other countries and Hawaii	
Alabama	2	Australia	2
Arizona	20	Austria	1
California	252	Cyprus	2
Colorado	38	Canada:	
Connecticut	1	Alberta	3
District of Columbia	3	*British Columbia*	18
Florida	1	Ontario	2
Georgia	1	Saskatchewan	4
Idaho	43	England	1
Illinois	1	*Hawaii*	2
Indiana	1	India	2
Iowa	1	Israel	2
Kansas	1	Mexico	1
Louisiana	1	Netherlands	2
Maryland	6	Spain	2
Michigan	1	Pakistan	3
Minnesota	1		
Missouri	1		
Montana	27		
Nebraska	6		
Nevada	9		
New Jersey	1		
New Mexico	4		
North Dakota	2		
Ohio	1		
Oregon	65		
Pennsylvania	5		
South Dakota	3		
Texas	6		
Utah	271		
Virginia	5		
Washington	75		
Wyoming	20		
Total	875		47

was a divisional meeting, 32 states, the District of Columbia, Hawaii, Canada, and 10 countries other than the United States and Canada were represented, with no region of the United States omitted.

In Utah, 20 communities were represented; there were 105 participants from Logan, 83 from Salt Lake City, 24 from Dugway, 14 from Ogden, and 11 from Provo.

The next annual meeting of the Pacific Division will be held in San Diego, 15 to 19 June 1959. George E. Lindsay, director of the San Diego Museum of Natural History, is chairman of the committee on arrangements.

ROBERT C. MILLER
California Academy of Sciences, San Francisco, California

Bacteriology

The 59th general meeting of the Society of American Bacteriologists will convene in St. Louis, Mo., on the evening of 10 May with an address by Sir Arnold Ashley Miles, director of the Lister Institute of Preventive Medicine, London. Attendance at the meeting is expected to reach 3000. A total of 406 scientific papers will be delivered among four divisions of microbiology: medical, general, agricultural and industrial, and physiological. Research findings will be presented at five sessions occurring simultaneously during the morning and afternoon meetings of each day of the convention, 11–14 May.

Five evening symposia are scheduled on the following topics: steroid metabolism, biology of cells modified by viruses or antigens, initiation of bacterial growth, progress in microbial genetics, and the interplay between infectious agents and phagocytic cells. The president's reception in honor of P. R. Edwards of the Communicable Disease Center, Chamblee, Ga., will be held at the Sheraton-Jefferson Hotel on 12 May. For additional information, write to: Dr. Leonard F. Laskowski, Department of Pathology, St. Louis University School of Medicine, 1402 South Grand Blvd., St. Louis, Mo.

Chemical Engineers

The 40th National Meeting of the American Institute of Chemical Engineers will be held in Kansas City, Mo., 17–20 May, in the Muehlebach Hotel, with an expected attendance of 1800. Sixteen sessions and symposiums at which more than 60 papers will be presented have been arranged by Fred Kurata, of the University of Kansas, chairman of the technical program. While several sessions will be on general chemical processing, a number will be devoted to aspects of the petroleum and petrochemical fields and jet and rocket fuels. National licensing and ways to improved technical reports also will be subjects of sessions. Another symposium will be on the growth potential of the heavy chemical industry in the central United States.

Self-Organizing Systems

An Interdisciplinary Conference on Self-Organizing Systems will be held 5–6 May at the Museum of Science and Industry, Chicago, Ill., under the cosponsorship of the Information Systems Branch of the Office of Naval Research and the Armour Research Foundation. The purpose of this conference is to bring together research workers in all fields of science who are concerned either with the development of self-adaptive information systems or with the conduct of research that may contribute to an improved understanding of cognitive, learning, and growth processes. Further information may be obtained from Mr. Scott Cameron, Armour Research Foundation, 10 West 35 St., Chicago 16, Ill.

Industrial Prospects in Nuclear Energy

A Conference on Industrial Prospects in Nuclear Energy is being organized by the European Nuclear Energy Agency of the Organization for European Economic Cooperation. The conference, sponsored by the Industrial Federations of OEEC member and associated countries, and by the Council of European Industrial Federations, is to take place in Stresa, Italy, 11–14 May. Its purpose will be to evaluate the commercial prospects for industry that are offered by nuclear energy, the probable markets in this field for materials and equipment, and the amount of investment required and its probable return.

Speakers at the conference will be drawn from industrial and governmental organizations in OEEC member countries, the United States, and Canada. Some of the sessions will be in the form of panel discussions, and several will be based on preliminary studies carried out by ENEA and circulated in advance to participants. During the conference there will be a visit to the nearby Italian Nuclear Research Centre at Ispra.

The conference has been designed for senior management in all the member and associated countries of the OEEC, and participation is being arranged through the industrial federations in these countries. Application forms and further information are available from the federations.

Microcirculatory Conference

The Seventh Microcirculatory Conference will hold its annual meeting in the Clinical Science Building, National Institutes of Health, Bethesda, Md., 4–5 May. The theme of the conference will be "Intravascular Phenomena." There will be an address by Sir Howard Florey on "Some properties of endothelium with special reference to the lymphatics," a paper on control of blood flow, and exhibits of various in vivo microvascular techniques.

Scientists interested in anatomy and physiology of the small blood vessels, as well as those interested in thrombotic and embolic phenomena, are invited to attend. For further details, write the secretary, Dr. B. W. Zweifach, 550 First Ave., New York 16, N.Y. For room reservations, write Dr. Murray Brown, National Institutes of Health, Bethesda 14, Md.

Idaho Academy

The Idaho Academy of Science has recently been formed in the state of Idaho. The purposes of the organization are to further the cause and activities of science in Idaho and to provide means of communication among the scientists and persons interested in science in that state. Two organizational meetings have been held, and the first regular annual meeting is scheduled to take place at the University of Idaho on 2 May. There are now more than 100 members of the academy.

Pan-American Ophthalmology Conference

Plans are going forward rapidly for the sixth Pan-American Congress of Ophthalmology, which will be held in Caracas, Venezuela, 31 January to 7 February 1960. Jesus Rhode of Caracas is executive president of the organizing committee for the congress, which will have headquarters at the Hotel Tamanaco.

Those who wish to participate in the program are urged to send titles and abstracts of papers, and applications for the showing of new films and exhibits, *before 1 May 1959* to the chairman of the program committee for North America, James H. Allen, Tulane University School of Medicine, 1430 Tulane Ave., New Orleans 12, La.

For detailed information about arrangements, write to Dr. Rhode, or to Dr. Hernandez Miliani, Comite Ejectivo, Apartado 5666, Chacao, Caracas. Dr. William L. Benedict, 15 Second St., SW, Rochester, Minn., is in charge of plans for transportation.

Geodetic Measuring

The American Geophysical Union is host for the International Association of Geodesy's Symposium on Electronic Distance Measuring Equipment that is to take place in Washington, D.C., on 5–12 May. Chauncey D. Leake, president-elect of the AAAS, will deliver the keynote address at the opening session. The technical sessions will be held in the Commerce Building. For information, write to Charles A. Whitten, Coast and Geodetic Survey, Washington 25, D.C.

AEC Test Reactor Meeting

The Atomic Energy Commission will conduct an unclassified technical information meeting on the construction, operation, and use of test reactors for representatives or organizations engaged in, or having expressed interest in, AEC and industrial test-reactor programs. The meeting will be held at the commission's National Reactor Testing Station, Idaho Falls, Idaho, 13–15 May.

Technical papers will be presented by representatives of the commission and its Argonne, Brookhaven, and Oak Ridge National Laboratories; and by representatives of the Battelle Memorial Institute, Phillips Petroleum Company, General Electric Company, Westinghouse Electric Corporation, and Pratt and Whitney Division of United Aircraft Corporation.

The meeting agenda also includes a panel discussion on the future use of test reactors in experimental programs. Commissioner John F. Floberg will be the guest speaker at a dinner to be held on 13 May.

The AEC's Idaho Operations Office and the Phillips Petroleum Company are cosponsoring the meeting. Inquiries should be sent to: Allan C. Johnson, Manager, Idaho Operations Office, Atomic Energy Commission, P.O. Box 2108, Idaho Falls, Idaho.

Forthcoming Events

May

17–20. American Inst. of Chemical Engineers, 40th natl., Kansas City, Mo. (F. J. Van Antwerpen, AICE, 25 W. 45 St., New York 36.)

17–21. American Ceramic Soc., 61st annual, Chicago, Ill. (C. S. Pearce, ACS, 4055 N. High St., Columbus 14, Ohio.)

17–21. Institute of Food Technologists, 19th annual, Philadelphia, Pa. (C. S. Lawrence, IFT, 176 W. Adams St., Chicago 3, Ill.)

17–23. Antibiotics, intern. symp., Prague, Czechoslovakia. (M. Heřmanský, Antibiotics Research Inst., Roztoky near Prague, Czechoslovakia.)

17–23. Mass Spectrometry, 7th, Los Angeles, Calif. (A. G. Sharkey, Jr., U.S. Bureau of Mines, 4800 Forbes Ave., Pittsburgh 13, Pa.)

18–20. Instrumental Methods of Analysis, 5th natl. symp., Houston, Tex. (H. S. Kindler, Director of Technical and Educational Services, ISA, 313 Sixth Ave., Pittsburgh 22, Pa.)

19–23. American Assoc. of Mental Deficiency, Milwaukee, Wis. (N. A. Dayton, Mansfield State Training School & Hospital, Mansfield, Depot, Conn.)

20–22. Education of the Scientist in a Free Society, conf., Milwaukee, Wis. (A. B. Drought, College of Engineering, Marquette Univ., 1515 W. Wisconsin Ave., Milwaukee 3.)

21–23. American Assoc. for the History of Medicine, 32nd annual, Cleveland, Ohio. (Miss E. H. Thomson, Yale Univ. School of Medicine, New Haven, Conn.)

21–27. Veterinary Cong., 16th intern., Madrid, Spain. (J. Jensen, General Secretary of Permanent Committee, Belstraat 168, Utrecht, Netherlands; or W. A. Hagan, Dean, Cornell Univ., New York State Veterinary College, Ithaca, N.Y.)

24–27. Chemical Inst. of Canada, 42nd annual conf., Halifax, Nova Scotia. (Chemical Inst. of Canada, 18 Rideau St., Ottawa 2, Ontario.)

24–29. American Tuberculosis Assoc., Chicago, Ill. (Mrs. W. B. White, 1790 Broadway, New York 19.)

24–29. Social Welfare, natl. conf. and annual forum, San Francisco, Calif. (National Conference on Social Welfare, 22 W. Gay St., Columbus 15, Ohio.)

25–27. American Gynecological Soc., Hot Springs, Va. (A. A. Marchetti, 3800 Reservoir Rd., NW, Washington 7.)

25–27. American Soc. for Quality Control, Cleveland, Ohio. (L. S. Eichelberger, A. O. Smith Corp., Milwaukee, Wis.)

25–27. Chemical Inst. of Canada, 42nd annual conf., Halifax, Nova Scotia. (Chemical Inst. of Canada, 18 Rideau St., Ottawa, Ontario, Canada.)

25–27. Telemetering, natl. conf., Denver, Colo. (R. Schmidt, AVCO Mfg. Co., 201 Lowell St., Wilmington, Mass.)

25–28. Smoking and Lung Cancer, and Pulmonary Emphysema, symps., American Trudeau Soc., Chicago, Ill. (H. W. Harris, Medical Sessions Committee, ATS, 1790 Broadway, New York 19.)

25–29. Transistors and Associated Semi-Conductor Devices, intern. conv., London, England. (Institution of Electrical Engineers, Savoy Pl., London, W.C.2.)

25–31. Electroheat, 4th intern. cong., Stresa, Italy. (International Union for Electroheat, 14, rue de Stäel, Paris 15e, France.)

26–29. American College of Cardiology, Philadelphia, Pa. (P. Reichert, 480 Park Ave., New York 22.)

27–28. Legal Environment of Medical Science, 1st natl. conf. (Natl. Soc. for Medical Research and Univ. of Chicago), Chicago, Ill. (Natl. Soc. for Medical Research, 920 S. Michigan Ave., Chicago 5.)

28–30. American Ophthalmological Soc., Hot Springs, Va. (M. C. Wheeler, 30 W. 59 St., New York 19.)

29–30. International Assoc. for Bronchology, 9th cong., Madrid, Spain. (J. Abello, IAB, Lagascar 13, Spain.)

30–5. Applications of Atomic Energy to the Petroleum Industry, symp., 5th

Saunders texts . . . . .

up-to-date and beautifully illustrated

New! Estok–ORGANIC CHEMISTRY

This short text for the one-semester or one-quarter course gives students of agriculture, home economics, veterinary science, and other fields a sound foundation in organic chemistry. The author covers only those reactions necessary to a basic understanding of the field.

Valuable introductory sections at the beginning of each of the 14 chapters outline the topics covered. Aliphatic and aromatic chemistry are considered concurrently after the first three chapters, an arrangement proven effective by experience in short courses. 31 tables give the student see-at-a-glance data on such subjects as: composition of a typical petroleum; structures and boiling points of some alkanes, olefins, acetylenes, alcohols and aldehydes; percentage acid contents of some typical fats and oils; synthetic addition polymers; nutritional data for selected foods; ortho-para and meta directing groups; physical constants of some aromatic hydrocarbons; etc.

Generous use of illustrations, review questions and practical everyday applications all combine to encourage student interest and make this a very usable text.

By George K. Estok, Ph.D., Associate Professor of Chemistry, Texas Technological College, Lubbock, Texas. 275 pages, illustrated. $5.50. *New!*

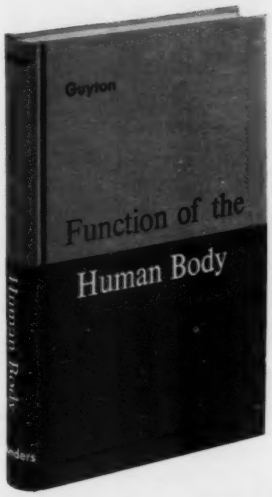
Burrows–TEXTBOOK OF MICROBIOLOGY

New (17th) Edition!—For over 50 years this popular text has served as a reliable guide for advanced undergraduate and graduate students, students of medicine and allied professions, research and laboratory workers, and physicians. It covers the entire field of microbiology and illustrates principles through examples of pathogenic organisms. The author points out the individual characteristics of fungi, bacteria and parasites. He gives a clear picture of structure, size, physiology, variation, affecting agents and activities.

In this revision, data on animal viruses has been expanded from one chapter to five. There is new material on tumor viruses. Sections on purine synthesis and nucleotide formation have been rewritten, and much new information is included on recently developed antimicrobial agents. Material on immunology has been revised with separate consideration of serological reactions. In discussions on virus diseases of man, essential facts about incidence and characteristics of the disease are given. Over 300 illustrations clarify text material and stimulate student interest. Superb new electron micrographs have been added.

By William Burrows, Ph.D., Professor of Microbiology, Department of Microbiology, University of Chicago. 954 pages, with 301 illustrations. $14.00.

New (17th) Edition!



New! Guyton–FUNCTION OF THE HUMAN BODY

Here is clearly written coverage of human physiology for the college student. Material is simply presented, eliminating the need for an extensive background in biology, physics and chemistry. Emphasis is placed on the regulatory mechanisms that make it possible for the basic living units of the body, the cells, to function without too many mishaps as long as the person lives. Selected abnormalities are discussed as examples of applied physiology. One of the best chapters on body fluids to be found in any undergraduate text is included. There is very little clinical material—just enough to illustrate the principles and to stimulate student interest.

Contents include: special areas of the circulatory system—regulation of respiration and the physiology of respiratory disorders—the thought processes and control of motor activities—the autonomic nervous system—sleep and psychosomatic effects—special sensory systems — the sex hormones — reproduction and fetal physiology.

By Arthur C. Guyton, M.D., Professor and Chairman of the Department of Physiology and Biophysics, University of Mississippi School of Medicine. 584 pages with 307 illustrations. $7.50. *New!*

gladly sent to college teachers for consideration as texts.

W. B. SAUNDERS COMPANY West Washington Square, Philadelphia 5

World Petroleum Congress, New York, N.Y. (C. E. Davis, General Secretary, 5th World Petroleum Congress, 527 Madison Ave., New York 22.)

31–3. Special Libraries Assoc., 50th annual conv., Atlantic City, N.J. (Miss M. E. Lucius, 31 E. 10 St., New York 3.)

31–5. Industrial Research Conf., 10th annual, New York, N.Y. (R. T. Livingston, Director, IRC, 409 Engineering, Columbia Univ., New York 27.)

June

1–3. Evolution, symp., annual, Saskatoon, Saskatchewan, Canada. (Mrs. L. C. Metivier, Royal Soc. of Canada, Natl. Research Bldg., 100 Sussex Drive, Ottawa, Ontario.)

1–4. American Dermatological Assoc., Atlantic City, N.J. (W. M. Sams, 25 Southeast Second Ave., Miami, Fla.)

1–4. Spectroscopy, 10th annual symp., Chicago, Ill. (G. W. Bailey, Borg-Warner Research Center, Des Plaines, Ill.)

1–5. International Silk Assoc., cong., Munich, Germany. (H. Bonvallet, 25, Place Tolozan, Lyon 1, France.)

1–6. International Commission for Northwest Atlantic Fisheries, 9th annual (by invitation), Montreal, Canada. (ICNAF, Forest Bldg., Carlelon St., Halifax, Nova Scotia.)

2–6. American Rheumatism Assoc., Washington, D.C. (E. F. Hartung, 580 Park Ave., New York 21.)

2–6. Rheumatic Diseases, 2nd Pan American cong., Washington, D.C. (R. T. Smith, West Point, Pa.)

3–5. Cellular Aspects of Immunity, symp. (by invitation), Royaumont (near Paris), France. (G. E. W. Wolstenholme, Ciba Foundation, 41 Portland Pl., London, W.1, England.)

3–7. American Assoc. of Bioanalysis, Cincinnati, Ohio. (L. D. Hertert, 490 Post St., Room 1049, San Francisco 2.

3–7. American College of Chest Physicians, Atlantic City, N.J. (M. Kornfeld, 112 E. Chestnut St., Chicago, Ill.)

3–10. Quantitative Biology, symp., 24th, Cold Spring Harbor, N.Y. (M. Demerec, Director, Biological Lab., Cold Spring Harbor, N.Y.)

4. Fine Structure as Related to Absorption, Synthesis and Transport in the Gastrointestinal Tract, symp., Atlantic City, N.J. (E. C. Texter, Gastroenterology Research Group, Medical School, 303 E. Chicago Ave., Northwestern Univ., Chicago 11, Ill.)

4. Petroleum Geochemistry, symp., New York, N.Y. (E. G. Baker, Esso Research and Engineering Co., P.O. Box 51, Linden, N.J.)

4–5. American Geriatrics Soc., Atlantic City, N.J. (R. J. Kraemer, 2907 Post Rd., Warwick, R.I.)

4–6. Endocrine Soc., 41st annual, Atlantic City, N.J. (H. H. Turner, 1200 N. Walker, Oklahoma City, Okla.)

4–7. American Medical Womens Assoc., Atlantic City, N.J. (Miss L. T. Majally, 1790 Broadway, New York 19.)

4–7. American Therapeutic Soc., Atlantic City, N.J. (O. B. Hunter, Jr., 915 19 St., NW, Washington 6.)

4–9. Electrolytes, intern. symp., Trieste, Italy. (Societa Italiana per il Progresso delle Scienze 7, Rome, Italy.)

5–7. American College of Angiology, 5th annual, Atlantic City, N.J. (A. Halpern, 11 Hampton Court, Great Neck, N.Y.)

5–7. American Gastroenterological Assoc., and American Gastroscopic Soc., annual, Atlantic City, N.J. (H. M. Pollard, University Hospital, Ann Arbor, Mich.)

6. American Acad. of Tuberculosis Physicians, Atlantic City, N.J. (O. S. Levin, P.O. Box 7011, Denver 6, Colo.)

6. International Cardiovascular Soc. (North American Chapter), Atlantic City, N.J. (P. T. DeCamp, 3503 Prytania St., New Orleans, La.)

6–7. American Diabetes Assoc., Atlantic City, N.J. (E. Paul Sheridan, 1 E. 45 St., New York 17.)

6–7. Society of Investigative Dermatology, Inc., 20th annual, Atlantic City, N.J. (H. Beerman, 255 S. 17, Philadelphia 3, Pa.)

6, 20, and *27.* Recent Advances in Medical Technology, symp., Staten Island, N.Y. (N. Colosi, Wagner College, Staten Island, N.Y.)

7–11. American Soc. of Heating and Air Conditioning Engineers, semi-annual, Vancouver, B.C., Canada. (A. V. Hutchinson, ASHACE, 62 Worth St., New York 13.)

7–13. Fertility and Sterility, 3rd world cong., Amsterdam, Holland. (W. W. Williams, 20 Magnolia Terrace, Springfield, Mass.)

8–12. American Medical Assoc., Atlantic City, N.J. (F. J. L. Blasingame, 535 N. Dearborn St., Chicago 10, Ill.)

8–12. Association for Research in Ophthalmology, Inc., Atlantic City, N.J. (L. V. Johnson, 10515 Carnegie Ave., Cleveland 6, Ohio.)

9–11. Canadian Federation of Biological Societies (Canadian Physiological Soc., Pharmacological Soc. of Canada, Canadian Assoc. of Anatomists, Canadian Biochemical Soc.), Toronto, Ontario, Canada. (E. H. Bensley, CFBS, Montreal General Hospital, 1650 Cedar Ave., Montreal 25, P.Q.)

9–11. Interferometry, intern. symp., Teddington, England. (ISI, Natl. Physical Laboratory, Teddington.)

9–12. Health Technicians, 6th intern. cong., Paris, France. (Secrétariat Général du VI[e] Congrés-Exposition International des Techniciens de la Santé, 37, rue Montholon, Paris 9[e].)

10–12. Gas Chromatography, 2nd intern. symp., East Lansing, Mich. (H. S. Kindler, Technical and Educational Services, ISA, 313 Sixth Ave., Pittsburgh 22, Pa.)

10–12. International Union of Crystallography, Stockholm, Sweden. (W. Parrish, Apparatus Commission, Philips Laboratories, Irvington-on-Hudson, New York.)

11–13. Society for Study of Development and Growth, symp., Madison, Wis. (W. P. Jacobs, SSDG, Dept. of Biology, Princeton Univ., Princeton, N.J.)

11–14. American Electroencephalographic Soc., Atlantic City, N.J. (J. K. Merlis, University Hospital, Baltimore 1, Md.)

11–14. Wilson Ornithological Soc., Rockland, Maine. (A. Bagg, Farm St., Dover, Mass.)

13–14. Society of Biological Psychiatry, Atlantic City, N.J. (G. N. Thompson, 2010 Wilshire Blvd., Los Angeles 57, Calif.)

13–22. Information Processing, 1st intern. conf., Paris, France. (U.S. Committee for the Intern. Conference on Information Processing, Box 4999, Washington 8.)

14–17. American Dairy Science Assoc., Urbana, Ill. (H. F. Judkins, 32 Ridgeway Circle, White Plains, N.Y.)

14–18. American Soc. of Mechanical Engineers, semi-annual, St. Louis, Mo. (O. B. Schier, II, ASME, 29 W. 39 St., New York 18.)

14–19. Society of Automotive Engineers, summer, Atlantic City, N.J. (Meetings Div., SAE, 29 W. 39 St., New York 18.)

15–17. American Neurological Assoc., Atlantic City, N.J. (C. Rupp, 133 S. 36 St., Philadelphia 4, Pa.)

15–17. Sintering and Related Phenomena, conf., Notre Dame, Ind. (G. C. Kuczynski, P.O. Box 145, Notre Dame.)

15–17. X-Ray Microscopy and X-Ray Microanalysis, 2nd intern. symp., Stockholm, Sweden. (G. Hoglund, Institutionen for Medicinsk Fysik, Karolinska Institutet, Stockholm 60.)

New Products

The information reported here is obtained from manufacturers and from other sources considered to be reliable, and it reflects the claims of the manufacturer or other source. Neither Science *nor the writer assumes responsibility for the accuracy of the information. A coupon for use in making inquiries concerning the items listed appears on page 1038.*

■ OPTICAL READERS for quartz-helix microbalances allow fine detection of extension. For load capacities ranging from 2 mg to 20 g, differential weight can be detected to 0.02 percent. (Microchemical Specialties Co., Dept. 743)

■ ANEMOMETER measures the energy transferred to a fluid from a thin electrically heated wire maintained at constant temperature. Wire temperature is maintained by a feedback circuit in which the anemometer wire constitutes one arm of a Wheatstone bridge. Current required to maintain wire temperature is related to fluid velocity. Frequency response extends from d-c to as high as 10 kcy/sec. Wires having hot resistance between 2 and 100 ohm may be used. Maximum current is 300 ma. Voltage output is 0.01 v/ma. (Shapiro and Edwards, Dept. 740)

■ INTEGRATOR for electromyogram curves is designed to be connected between the recording amplifier and galvanometer and to record the integral of the absolute value of input voltage. Integration periods of 0.1, 0.5, or 4 sec can be selected. Integrator output is linear in the deflection range 5 to 25 mm. A synchronizer permits starting the presentation of stimuli at the beginning of the integration period or starting the integration at the time stimuli are presented. Integration is expressed as a stored voltage. (Medical Electronics Development Co., Dept. 744)

■ HIGH-SPEED CENTRIFUGE accommodates glass or disposable plastic tubes of 1-, 0.5- and 0.25-ml size by use of polyethylene adapters. The centrifuge operates at 13,800 rev/min. A timer automatically stops the head after a preset interval of 1 to 30 min. (Clay-Adams, Inc., Dept. 728)

■ TISSUE-CULTURE DISHES for plaque, monolayer, and various organ culture studies include side arms for aseptic entry with either syringe needle or pipette. Precision ground tops are sealable with high-vacuum silicone stopcock grease. Dishes can be inverted on microscope stage for low-power observation. (Bellco Glass, Inc., Dept. 742)

■ NITROGEN ANALYZER for nondestructive determination of nitrogen in solids operates by neutron activation. The instrument consists of an instrument console and a detection unit. A pellet source of fast neutrons is located in the sample chamber of the detection unit. The neutrons, after thermalization, activate nitrogen nuclei. Analysis of the characteristic gamma radiation emitted by decay of the activated nuclei provides information of nitrogen content. Sample size is 0.6 ft^3; analysis time is 15 min. Accuracy is said to be comparable with that obtainable by the Kjeldahl method. (Schlumberger Well Surveying Corp., Dept. 735)

■ ULTRAMICROTOME, manufactured by C. Reichert, in Austria, achieves uniform advance of the specimen by thermal means. Total range of feed is approximately 300 μ. Section thickness of 200 A is said to be obtainable. A water-cooling device permits the system to contract rapidly. The knife holder can be used with metal or glass blades. A binocular magnifier and illuminator permit estimation of section thickness by observation of interference phenomena. Manual and motor drive are provided. (William J. Hacker & Co., Dept. 736)

■ CAPACITATIVE MICROMETER measures distance in terms of the capacitance change between the test surface and a noncontacting probe. The capacitance of the probe is compared with the capacitance of a reference micrometer-adjusted capacitor by means of a transformer-coupled bridge. The reference-micrometer displacement is proportional to the measuring capacitor displacement; thus the micrometer may be calibrated to read directly the distance being measured. Range of the instrument is 0 to 0.045 in. Accuracy is ± 1 percent. (Wayne Kerr Corp., Dept. 737)

■ GAS ANALYZER detects 10 parts per billion of pentaborane or decaborane and 100 parts per billion of diborane in air. The analyzer performs a colorimetric spot test. A test paper is prepared by applying a drop of reagent to filter paper. Air is pumped through the test paper; the number of pump strokes required to produce a color match with a reference is a measure of borane concentration. Upper concentration limits are 3 ppm of diborane and 1 ppm of pentaborane and decaborane. (Mine Safety Appliance Co., Dept. 739)

JOSHUA STERN
National Bureau of Standards, Washington, D.C.

PERSONNEL PLACEMENT

CLASSIFIED: Positions Wanted, 25¢ per word, minimum charge $4. Use of box number counts as 10 additional words. Payment in advance is required. **Positions Open,** $33 per inch or fraction thereof. No charge for box number.

COPY for classified ads must reach SCIENCE 2 weeks before date of issue (Friday of every week).

DISPLAY: Rates listed below—no charge for box number. Monthly invoices will be sent on a charge account basis — provided that satisfactory credit is established.

Single insertion	**$33.00 per inch**
4 times in 1 year	**30.00 per inch**
7 times in 1 year	**28.00 per inch**
13 times in 1 year	**27.00 per inch**
26 times in 1 year	**26.00 per inch**
52 times in 1 year	**25.00 per inch**

For PROOFS on display ads, copy must reach SCIENCE 4 weeks before date of issue (Friday of every week).

Replies to blind ads should be addressed as follows:
Box (give number)
Science
1515 Massachusetts Ave., NW
Washington 5, D.C.

POSITIONS WANTED

Biologist, Ph.D. bacteriology and general botany. Symbiotic nitrogen fixation; microflora of forages. Box 95, SCIENCE. X

Plant Physiologist (biophysical orientation); assistant professor, 4 years of university teaching experience. Author of numerous publications, excellent references. Seeks university or research position. Box 96, SCIENCE. X

POSITIONS WANTED

Economic Botanist-Horticulturist-Plant Physiologist; Cornell Ph.D.; teaching, research, and administration; publications. Box 4220, Washington 12, D.C. 4/24

Medical Student, 30; B.A. chemistry; 4 years' experience biochemistry, bacteriology. Seeks research assistant position May through August. Box 86, SCIENCE. X

Microbiologist, Ph.D., with teaching and research experience, including tissue culture, wants research position in cell biology. Box 91, SCIENCE. 5/1

Ph.D. Trained in medical microbiology, good background related basic medical science; since 1955 successful in supervisory research position with internationally known ethical company; 5 years' university association. Affable, imaginative, effective organizer and coordinator, administrative ability. Desires change for more responsible position with growth potential in research, development, or management. Box 88, SCIENCE. X

Ph.D., biochemistry; 5 years, analytical chemist, process control section, large industrial company, East. Medical Bureau, Burneice Larson, Director, 900 North Michigan, Chicago. X

Research Administrator. Ph.D.; 18 years' diversified experience in chemical and biological research and technical administration; 8 years in pharmaceutical industry. Box 84, SCIENCE. X

Need Russian or Czech Translations? Abstracts reasonable. Anthony Broshe, 2255 S. Drake Ave., Chicago 23, Illinois. X

Zoologist, Ph.D. Interested in teaching protozoology, parasitology, genetics, or vertebrate embryology. Combinations of preceding with beginning courses considered. Box 89, SCIENCE. 4/24

POSITIONS OPEN

(a) **Biochemist,** M.S. or Ph.D.; 400-bed general hospital; new diagnostic center and laboratory; college town in New Jersey, few miles from New York; $5000–$9000 dependent on qualifications. (b) **Organic Chemist;** laboratory established 1949, devoted entirely to research in medicinal chemistry, almost exclusively to organic synthesis; Pacific Coast. (c) **Instructor in Microbiology and Immunology;** duties include participating in teaching program for medical students and research; minimum $7000; Midwest. (d) **Physicians** interested in clinical research and administration and, also, **Industrial Medical Director;** major pharmaceutical company; opportunity to develop employee health program; East; excellent salaries dependent qualifications, $12,000–$20,000. S4-3 Medical Bureau, Burneice Larson, Director, 900 North Michigan Avenue, Chicago. X

Biochemist. $7938–$9138 (effective 29 June 1959), for medical laboratory in hospital located 17 miles from downtown Detroit. Ten pathologists, a bacteriologist, 29 medical technologists and five laboratory aides on staff. Ph.D. in chemistry and some experience as a biochemist in a medical laboratory required. Duties include supervision, teaching, and research. Contact A. Clark, Wayne County Civil Service Commission, 628 City-County Building, Detroit 26, Michigan. X

Biochemist, Physiologist or Biologist with strong biochemical interests, recent or 1959 Ph.D., desired to participate in basic research on cellular metabolism and renal transport mechanisms. May Institute for Medical Research, 421 Ridgeway Avenue, Cincinnati 29, Ohio. 1/16; 2/20; 3/20; 4/17

Botanist, assistant professor to teach plant anatomy and plant physiology, and do research. Send curriculum vitae and two references to Chairman, Biology Department, University of Wichita, Wichita 14, Kansas. X

POSITIONS OPEN

Experienced Biochemist with strong synthetic background for development work in expanding southern California company. Box 93, SCIENCE. X

Botanist-Bacteriologist. Ph.D. or equivalent, to teach bacteriology and some botany. Rank of assistant professor. Write Professor W. B. Stallworthy, Department of Biology, Mount Allison University, Sackville, New Brunswick, Canada. ew tf

Chemist, Ph.D., liberal arts college. $6000–$7000. Annual raises. Union College, Barbourville, Kentucky. 4/17, 24

Electrophysiologist-Biophysicist for university research (with some teaching optional) on electrophysiology of the eye. Ph.D. with experience in bioelectric potentials required, microelectrode techniques desirable. To start 1 September. Salary from $7000 depending upon training and experience. Box 80, SCIENCE. X

Hematologist, Immunologist, with some knowledge of clinical pathology; to take charge small, well-equipped laboratory, 75 percent developmental work. $500 to begin. Swihart Pathology Laboratory, 505 David Whitney Bldg., Detroit 26, Michigan. 4/24; 5/1

NEW WORLD-WIDE SUMMER PLACEMENT DIRECTORY, over 12,000 fascinating opportunities in all states, many foreign countries. Complete verified information including salaries. Send $3.00 now. CRUSADE, Sci., Box 99, Station G, Brooklyn 22, N.Y. eow

Plant Physiologist, midwestern university planning plant tissue culture program for September. Excellent opportunity for research and some teaching. Box 94, SCIENCE. X

Research Assistant, B.S. or M.S. to work for Ph.D. in biochemistry on fundamental aspects of hormone-enzyme interactions; $2155 per year and tuition free. Write to Dr. Gerald Litwack, Biochemistry Department, Rutgers University, New Brunswick, New Jersey. 4/17

Research Associate or Graduate Student to assist university Russian language biomedical literature study, New York area. Part- or full-time. Box 90, SCIENCE. 4/24; 5/1, 8

SCIENCE TEACHERS, LIBRARIANS, ADMINISTRATORS urgently needed for positions in many states and foreign lands. Monthly non-fee placement journal since 1952 gives complete job data, salaries. Members' qualifications and vacancies listed free. 1 issue, $1.00. Yearly (12 issues) membership, $5.00. CRUSADE, SCI., Box 99, Station G, Brooklyn 22, N.Y. ew

The University of Alberta invites applications for the position of **Professor and Head of the Department of Zoology.** Applicants must hold a Ph.D. degree in zoology and must have demonstrated ability in teaching, research, and administration. The starting salary will be $10,000 or higher.

The Department of Zoology comprises eight staff members, teaching and undertaking research in vertebrate and invertebrate zoology, physiology, and ecology. The department can offer full training for the M.Sc. and Ph.D.

Applicants for the position should send a curriculum vitae, list of publications, and the names of five references, **not later than 30 April 1959,** to Douglas E. Smith, Dean, Faculty of Arts and Science, University of Alberta, Edmonton, Alberta, Canada. X

The Market Place

BOOKS • SERVICES • SUPPLIES • EQUIPMENT

DISPLAY: Monthly invoices will be sent on a charge account basis—provided that satisfactory credit is established.

Single insertion	**$33.00 per inch**
4 times in 1 year	**30.00 per inch**
7 times in 1 year	**28.00 per inch**
13 times in 1 year	**27.00 per inch**
26 times in 1 year	**26.00 per inch**
52 times in 1 year	**25.00 per inch**

For PROOFS on display ads, copy must reach SCIENCE 4 weeks before date of issue (Friday of every week).

BOOKS AND MAGAZINES

Your sets and files of scientific journals

are needed by our library and institutional customers. Please send us lists and description of periodical files you are willing to sell at high market prices. Write Dept. A3S, CANNER'S, Inc. Boston 20, Massachusetts

SUPPLIES AND EQUIPMENT

FREE Subscription to AERO-GRAPH Research Notes, a technical publication on new developments in gas chromatography. We offer a complete selection of essential supplies and the Aerograph line of GLPC equipment.

Gas Chromatography

Send for your free subscription today

WILKENS INSTRUMENT & RESEARCH INC.
Box 313, Walnut Creek, California YEllowstone 5-1469

SUPPLIES AND EQUIPMENT

albino rats*

From the hand of the veterinarian to research.

HYPOPHYSECTOMIZED RATS

* CHARLES RIVER C D (Caesarean-derived)
* CHARLES RIVER S D (Sprague-Dawley descendants)
* CHARLES RIVER W (Wistar descendants)

THE CHARLES RIVER BREEDING LABS
Dept. B 1093 Beacon St. Brookline 46, Mass.

• HYPOPHYSECTOMIZED RATS

Shipped to all points via Air Express
For further information write
HORMONE ASSAY LABORATORIES, Inc.
8159 South Spaulding Ave., Chicago 29, Ill.

USE THIS EASY SELF-MAILER to obtain further information

17 April 1959

Readers' Service

Information Requisition

It's simple: Mark—Clip—Fold—Mail—No stamp required

This coupon is for your convenience—to facilitate your requests for further information about advertised products and items in Equipment.

From:

Name ..... **Position** .....

Company .....

Street .....

City ..... **Zone** ..... **State** .....
(Please print or type)

Mark, clip coupon—FOLD HERE along this line—mail

Postage Will be Paid by Addressee

No Postage Stamp Necessary If Mailed in the United States

BUSINESS REPLY MAIL
First Class Permit #12711 New York, N.Y.

Readers' Service

To: SCIENCE MAGAZINE
Room 740
11 West 42 Street
New York 36, New York

Fasten Here Only
Staple, Tape, Glue

17 April 1959

Readers' Service

Information Requisition

Use this easy self-mailer to obtain further information about items or literature from the New Products section as well as from advertised products.

NEW PRODUCTS

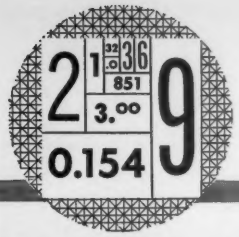
Circle below desired number corresponding to:

728 735 736 737 739 740 742
743 744

ADVERTISERS IN THIS ISSUE

In the below list, check page number of advertiser from whom you would like more information. If more than one item appears in ad, letters **A, B, C** are used to indicate particular items available in order of appearance in advertisement. Where more than one ad appears on page, **U** indicates upper ad, **L** lower ad, **I** inside ad, **M** middle ad, and **O** outside ad. The covers are designated by **IFC** (inside front cover), **IBC** (inside back cover), and **OBC** (outside back cover). Advertisements in Personnel Placement and Market Place are not keyed. A multiplicity of itms is indicatd by *. Readers are requested to specify on this coupon the particular item in which they are interested; otherwise, the request cannot be processed.

☐ IFC	☐ 987	☐ 988, A	☐ 988, B	☐ 989*
☐ 990	☐ 991	☐ 992	☐ 993	☐ 994
☐ 996	☐ 1030, LO	☐ 1031, A	☐ 1031, B	☐ 1031, C
☐ 1032, LO	☐ 1032, LI	☐ 1033	☐ 1034	☐ 1035, UI
☐ 1035, UO	☐ 1035, L	☐ OBC		



COMPUTER ENGINEERS & SCIENTISTS

Some News of Moment to Engineers

and Scientists who have participated in Operations Research & Systems Analysis—from Computer Department of General Electric

IN WASHINGTON, D. C. NEXT WEEK—
and in ensuing weeks, a group of men—whom the engineering world is beginning to call "scientific generalists"—will sit around a table with representatives of the Air Force, defining the problems and formulating the conceptual bases of an unprecedented DATA PROCESSING SYSTEM. This system will handle *evaluation and distribution of continuing variables on a scale never before attempted* and transcend present potentials in Man-Machine Relationships.

These men are drawn from many disciplines—mathematics, psychology, computer and systems engineering, philosophy, communications. In common, they have these attributes: unusual abilities to listen, synthesize, communicate, collaborate, and take a broad, all-encompassing view of multiphase problems.

The program, initiated early in 1958, is being conducted for the Air Force by General Electric's Computer Dept., from its Washington, D. C. offices and headquarters in Phoenix, Arizona.

CONCURRENTLY, SUPPORTING TEAMS OF SPECIALISTS ARE ENGAGING IN INTENSIVE RESEARCH. As a result, previous constraints limiting extremely high-volume, high-speed information storage and retrieval performance are disappearing. Major breakthroughs in computer concepts and technology are moving rapidly into the realm of the possible.

STEADY STAFF EXPANSION
in both Phoenix and Washington, D. C. has created a number of openings for specialists—from the "scientific generalist" to the engineer with 3 to 5 years' experience in the computer field.

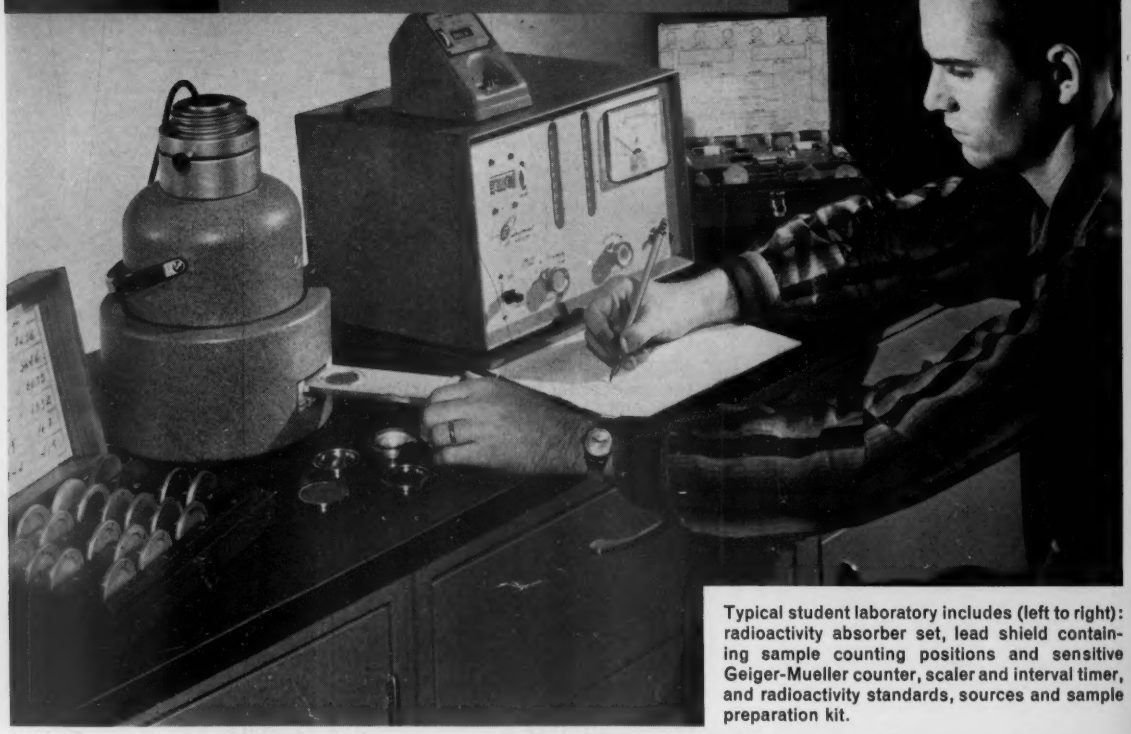
YOU ARE INVITED TO INQUIRE ABOUT THE SCOPE OF THE FOLLOWING ASSIGNMENTS:
INFORMATION SYSTEMS ANALYSIS (Index Concepts) PhD preferred • HUMAN FACTORS (Analysis & Training) PhD, MS • SYSTEMS INTEGRATION • COMMUNICATIONS ANALYSIS (Document Control) • COMPUTER SYSTEMS ANALYSIS (Reliability Factors, Hardware Specifications) • OPERATIONS ANALYSIS (Over-All Systems) • SYSTEMS ANALYSIS (Optimum Equipment Applications) • OPERATIONS ANALYSIS (Document Retrieval, Specifications) • LIAISON-AIR FORCE (Computer Systems & Component Specifications)

Write, in confidence, to: Mr. J. E. Torrey, Div. 74-WO
COMPUTER DEPARTMENT

GENERAL ELECTRIC

13430 N. Black Canyon Highway, P.O. Drawer 270, Phoenix, Arizona

NEW from nuclear-chicago



Typical student laboratory includes (left to right): radioactivity absorber set, lead shield containing sample counting positions and sensitive Geiger-Mueller counter, scaler and interval timer, and radioactivity standards, sources and sample preparation kit.

• complete laboratories and experiment manuals for student training in the use of radioisotopes

Here is one of a group of inexpensive, complete nuclear laboratories supplied with practical student experiments. Now a college instructor can choose from an extensive list the experiments which best fit his curriculum, and incorporate radioisotopes immediately into his present classes.

Custom-designed laboratories include radioactivity measuring instruments, radioisotopes, sample preparation equipment, unusual reagents. Experiments familiarize students with the fundamentals of tracer measurements and illustrate important chemical principles and methods *using radioisotopic techniques*. Technical aspects of radioisotopes have been kept to a minimum, and the amounts of radioactivity handled by the student are kept well below the safe maximum.

Nuclear-Chicago is the largest manufacturer of radioactivity measuring and recording instruments and has been a leader in the field for more than 12 years. We have had long experience in helping establish radioisotopic training courses in colleges and universities. The instrumentation which is included in these training laboratories falls into the categories of equipment for which the U.S. Atomic Energy Commission will consider making direct financial assistance to colleges and universities.

Our field engineers will be glad to assist any instructor in choosing the laboratory equipment and experiments best suited for his curriculum. Please write for further details on these laboratories or for more information on the AEC assistance program.

Fine Instruments - Research Quality Radiochemicals

nuclear - chicago
CORPORATION
237 WEST ERIE STREET · CHICAGO 10, ILLINOIS

ight):
ntain-
sitive
imer,
mple

als

es

er of
s and
ears.
adio-
cities.
train-
ment
will
lleges

struc-
xperi-
te for
infor-

go

LINOIS